T[illegible]
CARPENT[illegible]
JOYNT RU[illegible]

Fitted with LINES [illegible]
riouſly and generall[illegible]

USEFUL

In Meaſuring of

Magnitudes and Tim[illegible]

With ſeveral Uſeful Apen[illegible]
for ſeveral Imployment[illegible]

As *Saylors*, *Surveyors*, *G*[illegible]
and *Gaugers*, &c.

By *JOHN BRO*[illegible]

Printed for *John* and *Tho.* [illegible]
at their Shop at the [illegible]
in the *Great Minories*, [illegible]

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TO THE

READER.

Courteous Reader,

THe Uſe of this *nſtrument*, called the *Joynt-Rule* or *Triangular Quadrant*, hath been formerly Publiſhed to the World in Three ſeveral Impreſſions. One by me in 1661, of about Eight Sheets of Paper, being now diſpoſed of: Another under the Name of the *Semi-circle* on a *Sector*, by Mr. *John Templar* of *Brabrooke*, of which ſort ſome may yet be had, of about Nine Sheets: A third in 1671, of Fifty two Sheets

of Paper, yet to be sold by me in the *Minories* and others, as by Mr. *John Sellers* at the *Royal Exchange* and *Hermitage Stairs*, and by Mrs. *Wingfield* in *Crutched Fryars*, *London*, called the *Triangular Quadrant*: But, this last and best being too bulkey and dear, is one cause of the Printing of this, others being out of Print and hard to come by.

In this I have used as much plainness and brevity as the matter will bear; and as for the making of *Sun Dials*, for which I know no *Instrument* more convenient than this fitted for that purpose; it is here wholly neglected; requiring more Lines to explain it well then this whole Book, and being done largely in the *Triangular Quadrant*, there is no Practicioner in *Dialling* that knows the conveniency thereof, but will be willing to buy the Book and *Instrument* also.

This

To the Reader.

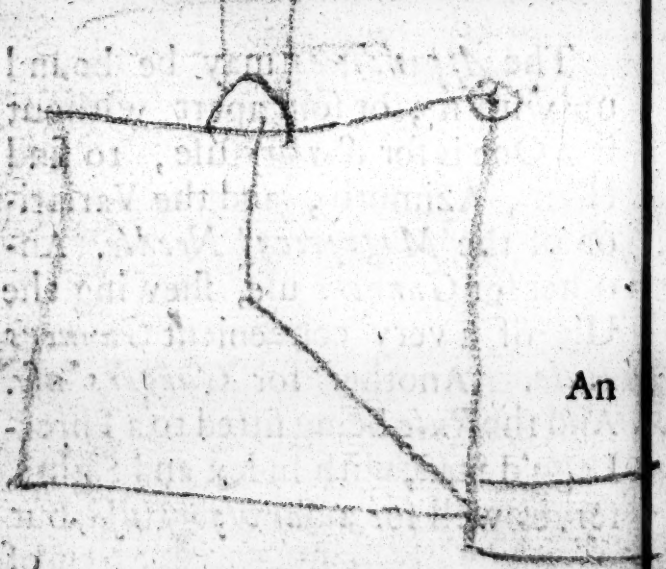
This is designed chiefly for young Work-mens use, as Carpenters, Joyners, Bricklayers, Painters, and Glasiers, *&c.* and the purchase thereof easy, wherein they may find many useful Things to imploy their spare Hours in, which will not likely cause any repentance for loss of time; but being attained, may prove many times of good use to them, and I hope may be well-pleasing to many.

The *Appendixes* may be bound up with it, or sold apart without it: One is for *Saylors* use, to find Hour, Azimuth, and the Variation of the *Magnetical Needle.* Another for *Gunners* use, shewing the Use of a very convenient *Gunners Rule.* Another for *Gaugers use.* And the *Rule* being fitted to a Three-Legg'd Staff, with Index and Sights, serves well for a *Surveyors use*; but

of

of these Additions more or less as you please. So for the present I rest and remain ready to serve you in well making this or any other *Mathematical Instrument*, at the *Sphere* and *Sun Dial* in the *Great Minories*, *London*, 1684.

JOHN BROWNE.



An

An INDEX
TO THE
Carpenters Joynt-Rule.

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THE

$$
\begin{array}{r}
240 \\
28 \\
\hline
45 \\
30 \\
\hline
15
\end{array}
$$

THE

CARPENTERS JOYNT-RULE

Fitted with LINES

Variously and Generally Useful

In Measuring

Magnitudes and Time.

As in Arithmetick and Geometry, Superficial and Solid Measure.

Brick-work and reducing it.

The finding of Heights and Distances, both neer and far off, the Hour, and Suns Azimuth, particularly and generally for any Latitude.

Also the Uses of the Glasiers, the Gaugers, and Masons Sliding Rules, many ways.

Also the Use of a New Gunners Rule, with Lines to find the Weight of Iron, Lead, or Stone Shot. the weight of Powder, for more, true, or less fortified Guns, of Brass, or Iron: With the Carteridges length and breadth, convenient.

The Use of the 30 and 40 Scales in Architecture great or small, and to find the length and Angles of Hips, Rafters, and Purloins, in any kind of Roof, Square, Taper, or Bevelling at any pitch or perpendicular.

With the Use of a Box and Magnetical Needle, to find the Hour and Azimuth, easily and generally, with the Variation of the Compass, Declination of Plains, and for Miners Use.

Sold by *John* and *Thomas Browne*, at the *Sun Dial* in the *Minories*, *London*, 1684.

Sold by John and Thomas Browne, at the Sun Dial in the Minories, London, 1634.

Errata in the Joynt-Rule.

Page	Line	Error	Correction
6	2	d	*f*
6	16	add	*by foot measure only*
10	18	add	*on*
10	28	add	9
18	25	add	*Pen*
22	9	add	592
22	10	add	474
26	2	add	*Pence*
26	8	add	*the*
27	13	225 read	125
27	14	frosh	*from*
29	14	feet	*Inches*
30	8	Inches	*Feet*
45	17	dele	5 *s.*
51	13	01476716	0476176
59	2	14	10
59	3	add	*Lines*
78	13	add	*Feet and* 100 *parts*
105	2	add	*the*
115	2	$37\frac{1}{2}$	$37\frac{1}{4}$

Of the Vse of Sliding Rules.

Page	Line	Error	Correction
12	14	25	15
34	25	Quotient	*Means*
35	16	132	123
38	9	$\frac{A}{10}$	$\frac{A}{10}$

Errata in the Part about Roofs.

Page	Line	Error	Correction
1	4	Level	*Bevel*
6	14	02	12
6	17	add *Near*	H B F
13	9	L B C	B L G
13	17	as thus	*thus, As*
14	6	A C	A D
14	6	B D	B C
15	13	74	97, 40
15	14	97 40	74
18	27	E V E	E V F
19	8	E V E	E V F
22	24	O B I	O B L
22	25	K L N	K A N
23	10	then	*the*
23	10	K A N	F A N
23	11	the	*then*

In the Gunners Rule.

Page	Line	Error	Correction
9	2	$\frac{1}{2}$	$\frac{1}{4}$

To Measure a Distance to a place afar off.

LEt A E represent a long Distance, not aproachable to be measured.

Set up the Instrument at A, and turn the Sights on the Head Leg, to the Mark afar off at E, and in that Line set up a Mark 100 Feet or Yards from A as at C, and screw the Rule fast there.

Then remove the Index 90 degrees from A E toward B, *viz.* at 60 on the loose Piece, and in that Line 100 Foot or Yards from A set up another Mark as at B.

Then remove the Instrument to B, and direct the sights on the Head Leg to A, and make it fast there, then turn the Index to E, and Note exactly the degrees cut, which in his *Example* is 78 8, the Angle at B; then the Angle at A being 90, the Angle at E must be 11.52, the Complement of 78, to 90 degrees.

1. Then first by Numbers and Sines Artificial say,

As the Sine of 11.52 the Angle at E, is to 100 on Numbers the side A B, so is the Sine of 78.8, the Angle at B, to 476.4 the Distance

ſtance A E, ſo alſo is the S. of 90 the Angle at A to 486 the ſide B E.

2. Or by the Natural Sines, and Lines, and Thred, As — S of 11.52 taken from o downward (or from 90 in the Azimuth Line) to = 2 in the Line of Lines called 100, now ſo is the — Sine of 78.8 from the ſame Sines, to = 476.4 on the Line of Lines.

So is — Sine 90 from the ſame Sines, to = 486 on the Line of Lines, at 972, becauſe of calling 2 a 100 in the firſt operation.

3. Or by the Line of Numbers only, meaſuring from C in a Line paralld to A B, as to D, being in a right Line between B and E; which in this *Example* is 7) Foot being meaſured exactly, then

As 21 the Difference between A B and C D, is to 100 the ſide A B, ſo is 10 the Diſtance between A and C, to 476 the Meaſure from A to B; ſo is 102 the meaſure between B and D to 486 the Diſtance from B to E.

Or by the Rule of Three, as 21 to 10, ſo is 100 to 476,4 A E, or as 21 to 100, ſo is 102, to near 486, multiplying 102 by 10, the product is 10200, which divided by 21, quotes 485 and $\frac{15}{21}$ the Extent B E.

To Measure a Distance to a place afar off.

LEt AE represent a long Distance, not aproachable to be measured.

Set up the Instrument at A, and turn the Sights on the Head Leg, to the Mark afar off at E, and in that Line set up a Mark 100 Feet or Yards from A as at B, and screw the Rule fast there.

Then remove the Index 90 degrees from AE toward B, *viz.* at 60 on the loose Piece, and in that Line 100 Foot or Yards from A set up another Mark as at B.

Then remove the Instrument to B, and direct the sights on the Head Leg to A, and make it fast there, then turn the Index to E, and Note exactly the degrees cut, which in this *Example* is 78.8, the Angle at B; then the Angle at A being 90, the Angle at E must be 11.52, the Complement of 78.8, to 90 degrees.

1. Then first by Numbers and Sine Artificial say,

As the Sine of 11.52 the Angle at E [illegible]
100 on Numbers the [illegible]
of 78.8, the Angle at B, to 479.4 [illegible]

stance A E, so also is the S. of 90 the Angle at A to 486 the side B E.

2. Or by the Natural Sines, and Lines, and Thred, As — S of 11.52 taken from 0 downward (or from 90 in the Azimuth Line) to = 2 in the Line of Lines called 100, now so is the — Sine of 78.8 from the same Sines, to = 476.4 on the Line of Lines.

So is — Sine 90 from the same Sines, to = 486 on the Line of Lines, at 972, because of calling 2 a 100 in the first operation.

3. Or by the Line of Numbers only, measuring from C in a Line parallel to A B, as to D, being in a right Line between B and E; which in this *Example* is 79 Foot more measured exactly, then

As 21 the Difference between A B and C D, is to 100 the side A B, so is 100 the Distance between A and C, to 476 the Measure from A to B; so is 102 the Measure between B and D to 486 the Distance from B to E.

Or by the Rule of Three, as 21 to 100, so is 100 to 476,4 A E, or as 21 to 100, so is 102, to near 486, multiplying 102 by 100, the product is 10200, which divided by 21 quotes 485 and $\frac{15}{21}$ the Extent B E.

THE DESCRIPTION AND SOME USES OF A JOYNT-RULE,

Fitted with a

THIRD PIECE,

To make it an

Æquilateral Triangle.

AS to the Form of it, the Title is enough, as to the Lines described thereon, briefly thus:

1. A Line of Inches and Foot Measure, to take Dimensions; or the length, breadth, and thickness of any Superficial or Solid Substance.

2. The Lines of Timber and Board Measure, shewing the length of a Foot of Timber at any squareness, or the length of a Foot of Board at any breadth.

3. The Line of Numbers, (with the Line of Pence and Farthings added to it,) to work any proportion in Arithmetick; performed by Multiplication and Division.

4. A particular Line for Bricklayers use, joined to 12 Inches, to shew the price of one Foot at any price *per* Rod.

5. A Line of Lines or equal Parts, in 10 or 12 Parts to 30, drawn from a Center.

6. Another of the same length, in 10 or 12 Parts to 40, as near it as may be, to be used with Compasses or by Inspection, in framing of English Rooffs.

7. A Line of Chords on the other Leg, and Points to divide a Circle into any number of Parts under 20, for Polygons.

8. All these Lines are placed on one side, and on the inward and outward edges.

9. On the other side a Line of 180 degrees of a Circle, on the moving Leg and loose Piece; drawn from a convenient Center on the head Leg, next the outside of the moving Leg and loose Piece.

10. Next

10. Next that more inward a Line of Shadows for finding of Heights and Distances.

11. Next that on the Moving Leg, more inward a Calender of Months and Days.

12. And a Line to shew the Suns right Ascensions; and Points to shew the Day when the Sun enters any whole Sign of the Zodiack.

13. On the same Moving Leg, more inward, is a Line of Natural Sines, to shew both the Hour and Azimuth for any one particular Latitude, for the Semidiurnal Ark of the longest Day in that Latitude, and numbred as Azimuths below from 0 to 130; and as Hours above on the same Line.

14. Lastly, On the same side and head Leg, is first a Line of equal Parts (or Lines) and a Line of Natural Sines next to it, abutting on one common Line, in which is the Center to the 180 degrees first mentioned.

15. More outward is another Line of Natural Sines, fitted to the Lines of Hour and Azimuth on the moving Leg, and called particular Scale for any one Latitude.

16. Next to this is the whole 12 Inches divided into 29 Parts $\frac{44}{100}$ for the Days of the Moons age.

17. Next to this is the ſame 12 Inches parted into 24 Parts for 24 Hours.

18. Next to this the ſame 12 Inches into 12 Parts for 12 Signs, or 12 Inches, and then each Inch into 30 Parts, for every degree of the Signs, or every four minutes of Time.

Theſe are the Lines which many times have their Names ſet to them. Their Uſes follow.

CHAP. I.

The Uſe of the Line of Inches or Equal Parts.

1. THE Inches are the Twelfth part of an Engliſh Foot, the Foot being juſt one half of the Rule, being open'd to a ſtrait line, which is (or ſhould be) exactly two Foot from one end to the other. Every Inch is parted into 8 or 10 parts, or 12 parts, as any one ſhall deſire it; the uſual way for Workmens uſe is into 8 parts, then every ſtroke is half a quarter of an inch, and the half inch is diſtinguiſhed from the quarter, and the half quarter from the quarter, as is u-

ſual

ſually done; ſo alſo is it diſtinguiſhed as plain as may be, if the inch is divided into 10 or 12 parts. Every inch is numbred with Arithmetical Figures from 1 to 12 at the Joynt, and from thence to 24 at the end; and ſometimes with 1, 2, 3, *&c.* in ſmaller figures, for a particular uſe as afterward. The uſe of theſe needs no Direction.

2. Secondly, Cloſe to theſe inches on the firſt foot is ſet the Line of Foot Meaſure, being the ſame Foot divided into 10 parts firſt, and then every of thoſe tenth parts into 10 more, being in all 100 parts; whoſe uſe is to reduce Foot Meaſure to inches, or inches to Foot Meaſure, being the moſt accurate way and eaſieſt in caſting up any Superficial Meaſure, the uſe being the ſame as the inches; *viz.* To take the dimenſions of any Superficial or Solid Subſtance, in Feet and Hundred Parts.

Alſo by placing the Inches and Foot Meaſure together, at any price *per* Square or Hundred Foot, counted on Foot Meaſure; on the Inches is the exact price of one: *Example*, At 50 *s. per* Square (or 100) what coſt 1?

Juſt againſt 50 on Foot Meaſure, is 6 inches for 6 pence, the price of 1, when an 100 coſt 50 *s.*

Again, if 1 Foot coſt 5 pence half penny, what coſt an 100 *d*? Juſt againſt 5 inches and a half, called 5 pence half penny, is on the Foot Meaſure near 46 or 45 *s*. and 10 *d*. But for any price *per* 100 under 10 *l*. and above 5 *l*. double the inches, by calling 12 inches 24 inches, and double the foot meaſure alſo, calling 10 at the joynt 10 *l*. and it ſupplies the defect: *Example*, At 8 *l*. 5 *s*. *per* 100 or ſquare, being counted at 82 and $\frac{1}{2}$ on Foot Meaſure, juſt againſt it on the inches is 9 $\frac{7}{8}$, which being doubled is 19 *d*. 3 *f*. for 1. But for above 10 *l*. *per* ſquare thus, *Example*, at 72 *l*. 15 *s*. 10 *d*. *per* ſquare, what is the price of 1? Set down 72 *l*. and by inſpection reduce 15 *s*. 10 *d*. to a Decimal Fraction, *viz*. 792, and ſet after 72,792, and double it, which is 14 *s*. 558, which by inſpection reduced, is 6 *d*. 3 *f*. very near; On the contrary the price of 1 given, what coſt 100? *Example*, At 15 *s*. 6 *d*. 2 *f*. *per* foot, call 15 *s*. 1500, reduce 6 *d* 2 *f*. to a Decimal *viz*. 542, which ſet under it, in all 15,542, whoſe half is 77 *l*. 14 *s*. 2 *d*. 2 *f*. the very near price of a ſquare at 15 *s*. 6 *d*. 2 *f*. *per* foot or 1.

3. Thirdly, On the other Leg, along or near to the other Foot or Twelve Inches, is ſet the particular Line for Bricklayers uſe; ſhewing the price of one Foot of Brick-work

at

at any price *per* Rod, or 272 Foot: and the contrary, at any price *per* Rod, to find the price of one Foot of Brick-work at a Brick and ½ thick. *Example*, At 5 *l. per* Rod, counted at 5 Inches from the Joynt, on the other Line in pricks is 4 pence 1 farthing and 2 thirds of a farthing.

Again at 7 *l.* 7 *s.* 6 *d. per* rod, is 6 pence half penny a foot; and at 6 *d.* a foot, counted on the pricked line at the stroke by 6, just against on inches is 6 *l.* 16 *s.* 6 *d. per* Rod, or 272 foot ¼, which is a Rod of Brick-work at one Brick and a half thick.

If the price *per* Rod be above 12 *l. per* Rod, then double the inches that represent the price in pounds, and call 6 inches 12 pound, then every point on the other line next it, is a half-penny, and the 5 pence is then called 10 pence, as before in foot measure. *Example*, At 14 *l.* 15 *s. per* Rod, one foot comes to 13 *d.* which is at 6 *d.* 2 *f.* as figured.

CHAP. II.

The Use of the Lines of Timber a Board Measure.

THE proper use of these Lines, is to shew at any breadth of a board given, to find how much in length makes one Foot of Superficial Measure.

And the Line for Timber Measure sheweth at any number of Inches a piece of Timber is square, how much in length makes one Foot of Timber or Solid Measure.

Example, At 6 inches broad, seek for 6 on the Line of Board Measure, which stands close to the beginning end of the Rule, and from thence to the end of the Rule forward, which is just 24 inches, is the length required to make one Foot superficial; for 6 times 24 is 144, and 144 inches is the true Area or content of one Foot Superficial.

Again, At 9 inches broad, seek for 9 on Board Measure, and from thence to the Rules end forward, is the true length to make one Foot Superficial Measure; for 16 times 9 is 144 as before.

Or if you apply the upper end of the Rule near an 100 on Board Measure, to the one edge of the board right a-cross the board, in the middle or mean breadth of the board, then the other edge of the board shall shew on the Line of Board Measure, the Inches and Quarters that go to make one Foot of Superficial Measure.

Then

Then having the true length of 1 Foot of Board, turn that length as many times as you can in the length of that Board, and ſo many times as you repeat it, ſo many Foot Superficial is in that Board, or Glaſs, or the like.

But if the Board be under 6 Inches broad, as ſuppoſe 4 Inches, then 4 doubled is 8, then ſeek for 8 on Board Meaſure, and 2 times from thence to the end forward, goes to make 1 Foot. But if when it is doubled it is under 6, double it again: as ſuppoſe 2 Inches broad, twice 2 is but 4, but 2 times 4 is 8, in ſuch a caſe 4 times from 8 on Board Meaſure to the end of the Rule, muſt go to make one Superficial Foot; for at 8 Inches broad, 18 Inches in length makes one Foot, and at 2 Inches broad the fourth part of 8, you muſt have 4 times 18 Inches, which is 72 Inches or 6 Foot, to make one Superficial Foot; and two times 72 is 144, the Inches in one Superficial Foot.

The Line of Timber Meaſure is almoſt the ſame as the Board Meaſure, for having found the Inches that any piece of Timber is ſquare, ſeek it on the Line of Timber Meaſure, and from thence to the end of the Rule, is the length to make one Solid Foot of Timber, at that ſquareneſs; *Example*, at 10 Inches

ſquare,

square, seek 10 on the Line of Timber Measure, and from thence to the forward end, where 36 is, is the true length of 1 Foot Solid, being full 17 Inches and a Quarter; for 10 times 10 is 100, and 17 times that is 1700, and 100 quarters and better is 28 Inches, in all 1728, the Cube inches contained in one Solid Foot of Timber.

But when a piece of Timber is under 8 Inches and a half Square, then double the Inches and quarters Square. *Example*, Suppose a piece of Timber be 5 Inches Square, 5 doubled is 10; then seek 10 on the Line of Timber Measure, then 4 times the length from 10 to the end of the Rule, is the true length to make one Foot of Solid Measure.

But if the side of the Square being once doubled, is not the line of Timber Measure, then double it again, and then 16 times the length from that number to the end of the Rule, is the true length of one Foot. *Example*, If a piece be but 2 Inches and a quarter Square, 2 Inches and a quarter doubled is but 4 Inches and a half, which comes not on the Rule; therefore I double 4 Inches and a half, and it makes 9 Inches which comes on the Rule; then I say 16 times the extent from on Timber Measure, to the Rule's end

end beyond 36, which is 21 Inches and 3 eight parts of an Inch, makes 28 Foot 4 Inches and $\frac{1}{2}$, the true length to make one Foot Solid at 2 Inches and $\frac{1}{2}$ Square.

The Uſe of the Table at the beginning end of the Board and Timber Meaſure, is to ſupply thoſe Numbers that come not on the Lines: As thus for Timber Meaſure, When a piece of Timber is one Inch Square, you ought to have 144 Foot in length to make one Foot; at 2 Inches Square 36 Foot long makes one Foot of Timber, but the laſt Rules in Timber and Board Meaſure, ſupplies the want of the Table ſufficiently, and in many caſes better than the ordinary Tables to every Inch.

CHAP. III.

The Uſe of the Line of Numbers, and the Lines of Pence and Time annexed to it, and Numeration thereon.

THE Line of Numbers is only the Table of Logarithms contrived on a Rule, and the ſeveral ranks of Figures in that Table,

ble, expreſt by the longeſt ſtrokes with figures ſet to them, and longer ſtrokes drawn between three lines to expreſs tenths of the former Units on Integers; and the ſhorteſt ſtrokes to expreſs the hundred parts of the firſt Integers; and as for the thouſand parts they are uſually eſtimated on moſt ordinary Lines of Numbers ſet on portable Rules.

And as in the operation by Logarithmes, the addition of the Logarithmes of any two Numbers together in one Sum, which Sum found out in the Tables, gives the Increaſe, or Multiplication of thoſe Numbers; ſo on the Line, the extent between any two ſtrokes, repreſenting any two numbers, being laid from a third Number increaſing, gives the ſame Product or Multiplication.

And in Diviſion the Logarithme of the Diviſor taken from the Logarithme of the Dividend, remains the Logarithme of the Quotient required.

So on the Lines, the extent between the Diviſor and 1 laid the ſame way, decreaſing from the Dividend, reaches to the Quotient.

In uſing of which Lines, the hardeſt matter is to know how to read the Lines, in their true

true and proper denominations; and for this purpose in the Year 1656, I published a small Book of the Line of Numbers, of which two or three Impressions are worn out; afterward to wit, in 1677, I contrived this Print annexed to this Book, which in several Lines, all of one kind eleven times repeated, do hold forth the true value of any part thereof, beginning at 00001 and ending at 10,000000, so that thereby the trouble of Numeration is made easie and ready to any one.

The Units, Tens, and Hundreds, in any Sum are distinguished by a long stroke with a Figure set to it drawn between 4 lines, the Tens are drawn between 3 lines, and every 5 Tenth longer than the other Tenths.

The Hundred Parts where they be expressed, as between 1 and 2, on two Foot Rules, are cut between 2 lines only, and every 5th cut somewhat longer than the rest for distinction sake; but between 2 and 4 every two tenths is only expreſt, and between 4 and 10 every tenth and half tenth is only expreſt.

Lastly, The thousandth part of any Integer is to be estimated by the eye, on most Lines of Numbers on portable Rules.

This

This is the proper reading of the Line of Numbers, when 10 at the end represents ten Integers, as on the fifth line on the Paper Print, and every line under the fifth increaseth by 10, as by the figures is apparent, and every line above the fifth is decreased by 10, as is expreſt by the figures alſo.

Note, That every line on the Paper Print being but the ſame thing eleven times repeated, you may work any Queſtion by one Line only as well as by the eleven, but then the increaſe or decreaſe of the places is not ſo certainly expreſt but underſtood.

As in uſing the Logarithmes:

The Logarithm of 20 is	1,3010300
The Logarithm of 200 is	2,3010300
The Logarithm of 2000 is	3,3010300
The Logar. of 20000 is	4,3010300

And ſo forward the Numbers are the ſame except the firſt Figure, called the Characteriſtick, which on the Print is expreſt by ſo many Lines one under another.

Thus much as to Numeration, more being learned by one hours ſhewing with Practice, than by ten hours Reading.

The

The Line of Money on the Rule, begins at 1 farthing near the first 1, and ends at 24 pence, being 2 *s.* or one tenth of a Pound *Sterling*, just at 10 on the Line of Numbers, and every penny being figured is easie to read.

But on the Paper Print those pence, farthings, and tens of farthings, stand in their true Decimal Places: *Example*, The true Decimal Fraction to express 10 *d.* 3 *f.* is 0,044791 6, but on the Paper Print you can see only 00448, which will serve in any ordinary Practice.

The Line of Time is only to every Day, and every Day is expreſt to 20 Days; and every tenth Day to 180, then every Month onely to 5 Years, is plain enough for any to read; whose chief use is to shew the Interest of 100 *l.* for any number of Days, or 10 *l.* or 1 *l.* or 1 tenth of a Pound, being 2 *s.* by inspection, and the Interest of any other odd Sum by operation. Thus just against 9 Days found in the fourth Line of Numbers, in the Line of Pence, just under it is 2 *s.* 11 *d.* 2 *f.* the Interest of 100 *l.* for 9 Days at 6 *per Cent.* and in the Line of Pence just over 9 Days, is 3 *d.* 2 *f.* ½ for the

Interest

Intereſt of 10 *l.* for 9 Days, and in the next Line of Pence upward, is the Intereſt of 2 *s.* 9 days, *viz.* 1 *ſ.* $\frac{4}{10}$.

CHAP. IV.

Of Multiplication, Diviſion, Reduction, Proportion, Rule of Three and Practice, by the Line of Pence and Time.

THE manner of reading the Line being well known, as is largely worded in the Triangular Quadrant, Chap. I. then for Multiplication the way of operation by the Line of Numbers is always thus:

The extent from 1 to the Multiplicator, taken with a pair of Compaſſes on the Line of Numbers, being laid the ſame way on the ſame Line of Numbers, from the Multiplicand, ſhall reach to the Product. Which Product is expreſt by as many Figures as is in the Multiplicator and Multiplicand, and always of one leſs when the two firſt Figures of the Product are greateſt, and more than four

four Figures in the Product, must be adjusted by multiplying the last Figures by the Head or Pen.

Example, By the Lines on the Printed Paper pasted.

Let 125 be multiplied by 16. The extent from 1 on the fourth Line to 16 on the fifth Line next under it, shall reach the same way from 125 in the sixth Line to 2000 in the seventh Line, which is expresly numbred 2000 the true Answer, containing but four Figures, because the two first Figures in 2000 is more than 12, or 16, the two first Figures of the Multiplicator and Multiplicand.

Again, Let 498 be multiplied by 85; The extent from 1 to 85 two Lines under one, shall reach from 498 to 42330; first the Lines shew 42300 plainly, but the 30 more, is found by multiplying of the two last Figures by the Head or Pen.

The same Work by one Line is done as truly, and if your Line be large more true, but your Reason must guide you as to the number of places, together with the Rule before expresst, and you may work it any way, either backward or forwards, still ob-

 serving

ſerving to lay the ſecond extent, the ſame way, as you took the firſt extent from 1, and this is general in all or the moſt Operations by the Line of Numbers.

Diviſion by the Line of Numbers.

The extent of a pair of Compaſſes from the Diviſor to 1, being laid the ſame way from the Dividend, reaches to the Quotient: Conſiſting of as many Figures as the Diviſor may be written times under the Dividend, as Integers by the Pen, and the remaining Fraction, is always a Decimal Fraction, and is reduced to the Vulgar Fraction, by ſetting the ſame extent the contrary way from the Decimal Fraction, gives the Vulgar Fraction.

Example,

In 595 Gallons, how many Beer Barrels? The extent from 36 to 1, being laid the ſame way from 595, gives 16 Beer Barrels, and the Decimal Fraction over is .527: then the ſame extent, laid the contrary way from .527 gives 19 Gallons over, the true Vulgar Fraction found out by dividing by the Pen.

Again,

Again, If 25 *s.* and 6 *d.* is to be parted among five Men and a Boy, allowing the Boy a half share.

The extent from 5.5 to 1, shall reach the same way from 25.5 to 4 *s.* 64 being 4 *s.* 7 *d.* 2 *f.* $\frac{1}{2}$ one Mans share, for five times 4.64 is 23.20, then 2.32 the half of 4.64 added, makes 25.52 a little more than 25 *s.* 50 the first Sum to be parted, or the extent from 5 5 to 1 shall reach from 1 *l.* 5 *s.* and to 4 *s.* 32 parts; then right against 32 counted on Numbers is 7 *d.* 2 *f.* $\frac{2}{3}$ of a *Farthing*, one Mans share.

Of Mean Proportions.

Mean Proportions are of Three sorts, *viz.*, *Arithmetical*, *Geometrical*, and *Musical*.

Arithmetical, is the half Sum of the two Extream Numbers added together: Thus, 21 the half Sum of 24, and 18 added, is a Mean Proportion *Arithmetical* between 24 and 18 the two Extreams.

The *Geometrical Mean Proportion*, is the Square Root of the Product, of the two Extreams, multiplied one by the other. Thus

the *Geometrical Mean* between 25, and 14 is 18.7, being the Square Root of 350 the Product of 25 and 14 multiplied being found by the Line of Numbers, in the true middle between the two Extreams.

The *Musical Mean* is thus found. As the *Arithmetical Mean* to one Extream, so is the other Extream, to the *Musical Mean*. Thus the extent from 19.5, the half Sum of 25 and 14, to 25 one Extream, reaches from 14 the other extream, to 17.95 the *Musical Mean*.

Of the Rule of Three.

The *Rule of Three*, is only *Geometrical Proportion*, between four or more Numbers, continued or discontinued: As thus for *Example*, The Space on the Line of Numbers between 1 and 8, divided into Three parts will be thus, 1.2.4.8. increasing, or 8.4.2.1 decreasing. For, If one Yard cost 2 *s.* four Yards will cost 8 *s.* Or if 8 *s.* pays for four Yards, then 2 *s.* will pay for one Yard.

Or thus in Proportion discontinued, As 8 to 12, so is 19 to 28.50, which by the Pen is wrought thus, Multipiy 19 the third, by

by 12 the second, the Product is 228, which divided by 8 the first Term, the Quotient is 28 $\frac{4}{8}$ the fourth Proportion required.

By the Line of Numbers the Rule is always thus, The extent from the first to the second, shall reach the same way from the third to the fourth. Thus the extent from 8 to 12, reaches the same way from 19 to 28.50 (or 28 and a half.)

The chief care in the *Rule of Three* (by the Pen especially) is, to order the Terms aright, by considering whether the fourth Term required should be more or less, for when more, the Divisor is less, and when less the Divisor is more.

Also to Note, That the term of Demand is always the third Term, and the other Term of the same Denomination always the first, then the remaining Term is the second, and the required Term the fourth; then always by the Line, the extent from the first to the second, reaches the same way, from the third to the fourth: As in the *Examples* above.

Of Reduction.

As one Denominator to his Numerator, ſo is the other Denominator to the inquired Numerator, and the contrary. *Example*, in 592 Shillings, how many Pounds?

The extent from 20, the Shillings in 1 Pound to 1, ſhall reach the ſame way from 592 to 29 *l.* 6, being 29 *l.* 12 *s.*

Again in 1 ¼ Ells how many Yards? As 5 Yards to 4 Ells, ſo is 592 to 473, the Ells in 592 Yards.

Note, That *Reduction* from 10 to 12, is done by Inſpection by the Inches and Foot Meaſure. And Pounds, Shillings, Pence, and Farthings, to Decimals by the Line of Numbers and Pence.

Of the Rule called Practice.

This is no other then the *Rule of Three* abbreviated.

For this purpoſe on the Paper Print is added the Line of Pence and Farthings, being the Decimal Fractions of One Pound *Sterling*

(or

(or Twenty Shillings) and the ſame Line is added to the Line of Numbers on the Rule, to two Radiuſſes, as conveniently as may be in that length, and the uſes of them in brief may be thus:

1. At any price *per* 100, what coſt 1 (or the contrary) at any price for 1 what coſt 100?

For any price *per* 100 under 2*s.* count thus, Seek the price *per* 100 on the Line of Pence, and one hundredth part thereof is the exact Anſwer.

Example, At 2 *d.* 2 *f.* *per* hundred, the price of one is 2 and $\frac{1}{2}$ hundred parts of one Penny in hundred parts, or one tenth of a Farthing. For looking on the Print for 2 *d.* 2 *f.* the price of one hundred, on the Line next above it is the price of 10, *viz.* One Farthing, and on the next Line is one tenth of a Farthing the exact Anſwer.

Again, At 7 *d* 2 *f.* *per* 100, is in the Line next over it 3 Farthings for 10, and in the next Line above 03 tenths of a Farthing for 1; which is 750 parts of one Penny in a 1000 parts.

Thus by the Paper print, annexed to the Book, this Rule is general at any price whatsoever, Having found the Price of a 100, on the Line of Numbers or Pence, on any one Line, the price of 10 is in the first Line just over it, and the price of 1 in the second Line right over it. *Example*, At 7 *l.* 10 *s. per* 100 found in the fifth Line, right over it in the fourth Line is 15 *s.* for 10, and in the third Line next above it is 18 *d.* the price of 1.

And on the contrary, having the price of 1, seek it on the Line of Numbers or Pence, and just against it in the Line next under it is the Price of 10, and in the second Line right under it is the price of 100. *Example*, If 1 cost 5 *d. farthing*, which is found on the third Line, just under it is 4 *s.* 4 *d.* 2 *f.* the price of 10, and on the next Line under that being the fifth Line, is 2 *l.* 3 *s.* 8 *d.* the price of 100.

But if the 100 contains 112 *l.* or any other Sum, then one motion of a pair of Compasses resolves the Question; as thus for *Example*, At 3 *l.* 12 *s.* for 112 *l.* what cost 1?

The

The extent from 112 in the seventh Line, to 3*l.* 12 in the fifth Line, shall reach the same way from 1 in the fifth Line, to 7 *d.* 3 *f.* in the third Line.

2. But by the Line of Pence set by the Line of Numbers on Two Foot Rules, in the length of Two Foot, the 24 Pence being the greatest Number expreſt on the Rule, If you count 10 at the end where 24 Pence is, .01 then 1 in the middle of the Rule is 001, and 1 at the beginning is 0001, just as it is on the Print.

Then the same Directions serves in the use.

But for the more convenient using it in ordinary Affairs, let 10 at the end represent 10*l.* then 1 in the middle is 1*l.* and 1 at the beginning 2 *s.* Then thus by the Rule for any price *per* 100 between 2 *s.* and 10*l.* by Inspection only.

Example, At 4 *s.* *per* 100 counted at 2 in the first part, on the Line of Numbers, just against it on the Line of Pence is 1 *farthing* and $\frac{22}{100}$ parts of a *farthing* for one.

Again, at 2 *l.* *per* 100 counted at 2 on Numbers in the second part, just against it on the Line of Pence is 4 *d.* 3 *f.* $\frac{1}{4}$ for 1. And

And on the contrary, at 4 *d.* for 1, what cost 100? Just against 4 *d.* on the Line of is 1 *l.* 13 *s.* 4 *d.* on the Line of Numbers.

3. This is the Rule for Sums between 2 and Ten Pound the most usual, for greater Numbers count thus: As for any between 10 *l.* and 1000 *l.* count the Tens of Pounds at 1, 2, 3, 4, and in thd first part and double it for the Answer in Shillings; then count the Unites of Pounds as before, and the two Sums added is the exact Answer.

Example, At 82 *l.* 10 *s.* 4 *d. per* Square of 100, what cost 1?

First 8 the Tens of Pounds doubled counted at 8 in the first part is 16 *s.* the Answer in Shillings, then the 2 *l.* 10 *s.* 4 sought as before on the Line of Numbers, just against it on the Line of Pence is 6 *d.* and of a *Farthing*: In all 16 *s.* 6 *d.* 0 *f.* $\frac{1}{4}$, the Answer.

Again, On the contrary, the price of one given, to find the price of a 100, *Example*, At 16 *s.* 8 *d.* 2 *f.* for 1, what cost 100? Seek for 16 *s.* being at 8 on the first part which now is read 80 *l.* then just against 8

2 *f.* counted on Pence, on the Line of Numbers is 3 *l.* 10 *s.* and 8 *d.* In all 83 *l.* 10 *s.* 8 *d.* the true price of 100 at 16 *s.* 8 *d.* 2 *f.* for 1.

Thus these two Lines performing this by Inspection for any 100, or 1, will by one Operation with Compasses, give the price of any odd Sum under 100 Pound at any other rate, or as 112 Pound the great hundred, or 272 Foot, being a Rod of Brick-work, as in these *Examples.*

If 17 Yards of Cloth cost 19 *l.* 2 *s.* 6 *d.* what cost 19 Yards and $\frac{1}{4}$? The extent on the Line of Numbers from 17 to 19.225, shall reach the same way from 19.5, to 21 *l.* 18 *s.* 9 *d.* at 21.9375, though indeed, on these small Lines on the print you cannot certainly see so many Figures.

2. If 17 C. $\frac{1}{4}$ of any Commodity cost 6 *l.* 4 *s.* 3 *d.* for the Carriage, what cost One hundred weight? The extent from 17.75 to 6 *l.* 4 *s.* 3 *d.* at 6.2125, shall reach the same way from 1 to 3.5 which is 7 *s.* (when 1 at the beginning is 2 *s.*)

3. If 112 *l.* cost 7 *s.* what cost 1 *l*? The extent from 112 to 3.5 on the Line of Numbers, shall reach the same way from 1 in the middle

middle to 3 *farthings* on the Line of Pence.

4. If 326 *l.* 6 *s.* 8 *d.* pay 40 *l.* 1 *s.* 6 *d.* to a Tax, what muſt 1 *l.* pay at the ſame rate? The extent from 326 *l.* 333 (or one third) to 40.075, ſhall reach the ſame way from 1 *l.* to 01 *l.* 250, which is 2 *s.* 6 *d.* or when 1 in the middle is called 2 *s* for right againſt 250 counted on Numbers is 6 *d.* on the Line of Pence.

5. If 100 *l.* have 6 *l.* for its Intereſt for one Year, what Intereſt is due for 76 *l.* 17 *s.* 6 *d*? The extent from 100 to 6, ſhall reach the ſame way from 76.875 to 4.6125, for 4 *l.* 12 *s.* 3 *d.* for right againſt 125 on Numbers is 3 *d.* on the Line of Pence.

6. If 3 Yards $\frac{1}{4}$ of Ribbon coſt 7 *d.* 2 *f.* what coſt 11 Yards and half? The extent from 3.75 counted on numbers to 7 *d.* 2 *f.* on the Line of Pence, ſhall reach the ſame way from 11.5 on Numbers to 23 Pence on the Line of Pence.

7. If 5 Ounces and $\frac{1}{2}$ coſt 18 *d.* 2 *f.* $\frac{1}{4}$, what coſt 1 *C.* 2 *q.* and 16 *p*? The Anſwer is 41 *l.* 8 *s.* 0, wrought thus at two workings.

1. As 5 Ounces and $\frac{1}{2}$ counted on Numbers to 18 *d.* 2 *f.* $\frac{1}{4}$, on the Line of pence, ſo is 16, the Ounces in one Pound weight, to 4 *s.* 6 *d.* the price of one Pound. 2. The

2. The extent from 1 pound to 4 *s.* 6 *d.* at 2.25 on Numbers, shall reach the same way from 184, the pounds in 1 *C.* 29. and 16 *l.* to 41 *l.* 8 *s.* 0 *d.* the Answer to the Question.

Thus by right stating the Question, may any operation be done by the Line of Numbers and Pence, exactly in small Numbers, and near the truth in greater Sums, to prevent mistakes by the Pen.

CHAP. V.

The Use of the Line of Numbers in Superficial Measure.

1. AS the breadth in inches to 12, so is 12 to the inches long to make one Foot.

2. The extent from the breadth in Foot Measure to 1, shall reach the same way from 1 to the length in Foot Measure to make 1 Foot.

3. The extent from 1 to the length in feet, shall reach the same way from the breadth in feet, to the content in feet.

4. The

4. The extent from 12 to the breadth in inches, ſhall reach the ſame way from the length in feet to the content in feet.

5. As 1 inch to the breadth in inches, ſo is the length in inches to the content in ſuperficial inches.

6 As 144 to the breadth in inches, ſo is the length in inches to the content in inches.

Of Land Meaſure.

1. As 9 to the length in feet, ſo is the breadth in feet to the content in yards.

2. As 14.0625 the Feet in a ſquare Ell to the breadth in Feet, ſo is the length in Feet to the Superficial content in Ells.

3. As 1 Perch to the breadth in Perches, ſo is the length in Perches to the content in Superficial Perches like the firſt Perch, Rod, or Pole.

4. As 160 (the perches in 1 Acre) to the breadth in perches, ſo is the length in perches to the Acres.

5. As

5. As 10 to the breadth in Chains and Links, so is the length in Chains and Links to the content in Acres, (10 square Chains being 1 Acre.)

6. As the length of a Customary Perch, Pole or Rod, to the Statute Perches length; so is the content in Statute Acres to the content in Customary Acres, at twice turning of the Compasses.

7. To find out by what Scale a Field is plotted, measure the Field by any Scale as near as you can estimate, and note the Area.

Then the middle between the Area last found, and the Area set down in the Plot, counted on the Line of Numbers, shall reach on the same Line of Numbers from the estimated Scale to the true Scale.

8. As the length of any Oblong in Perches to 160, so is 1 Acre to the breadth in Perches required to make 160 Perches or 1 Acre.

Or as the length in Chains to 10, so is 10 to the breadth in Chains to make one Acre.

Or

Or as the length in Feet to 43560 (the Feet contained in one Square Acre.) so is 1 to the breadth in Feet to make one Acre.

CHAP. VI.

To Measure Circles, Elipses, Triangles, Polygons and Trapezia's, Square and Cube Roots.

1. AS 10 to the Diameter, so is 31.416, to the Circumference about.

2. As 31.416, to any other Circumference; so is 10 to the Diameter.

3. As 10 to 8.862, so is any other Diameter, to the side of the Square equal.

4. As 10 to 7.071, so is any other Diameter to the side of the Square inscribed.

5. As 10 to any other Diameter, so is 78.54, twice to the Area.

6. As

6. As 31.416 to any other Circumference, ſo is 78.54, twice to the Area.

7. The middle between 78.54 and any other Area of a Circle, ſhall reach from 10 to the Diameter, and from 31.416 to the Circumference, and from 8.862 to the ſide of the Square equal, and from 7.071, to the ſide of the inſcribed Square.

8. The middle between the ſhorteſt and longeſt Diameters of an Oval, is the Diameter of a Circle, equal to the Oval or Eliplis.

9. As 100 the Square of 10, a fixed Diameter, to the product of the two Diameters of the Eliplis: ſo is 78.54 the Area for 10 to the Area of the Eliplis required.

10. As 1 to the half Diameter, ſo is half the Circumference to the Area.

11. As 1 to the Radius of any Segment, ſo is half the Arch to the Area of that Segment proceeding to the Center, as a Quadrant, a Sextance, &c.

12. For other Segments find the Diameter of the Circle it is part of, and the length of the Arch, by meaſuring or thus:

1. First, For the Diameter, ſquare half the Segments Diameter (or Chord) divide the product by the Segments Altitude or Sine, then the quote and ſine added is the Diameter, the half is Radius or Semidiameter

2. Secondly, The Square Root of the Sum of the ſquares of the Segments Altitude or Sine, and half his Diameter ſhall be the Chord of half the Segments Arch.

3. Thirdly, The true length of the Segments Arch, is twice the length of the Chord of half the Segment, more one third part of the difference between them and the Segments Diameter.

Then meaſuring the Segment by the 11th Rule and the Triangle being ſubſtracted, remains the Area of the Segment required.

13 As 2 to the baſe of any right lined Triangle, ſo is the Perpendicular to the Area of the Triangle.

14 As 2 to the Diagonal Line from any two corners of a Trapeſia, ſo is the Sum of the two Perpendiculars to the Area.

15. To

15. To find the Area by the three sides only.

Add the Three sides together, to find the Sum, the half Sum, and the difference between the half Sum and each side severally. Then multiply one difference by another difference, and then this first product by the remaining difference: And lastly, this second product by the half Sum, after the manner of continual Multiplication.

Then Lastly, the Square Root of this last product, is the Area of the Triangle required. Thus the three sides 6, 8 and 10, have 24 for the Area.

16. As 1 to the Measure from the Center to the middle of one side of any Poligon, so is the half Sum of the sides round the Poligon, to the superficial content.

17. All many sided Irregular Figures are best measured by reducing them to Triangles or Trapesi a's.

18. The middle between the length and breadth of any Long Square being measured with Compasses, upon a true Line of Numbers, is the side of a Square equal to that

long Square, uſed to find the Square equal in meaſuring of Timber.

19. In finding the Square Root of a Number conſiſting of even Figures, the middle between 10 at the right end, and the number, is the Square Root of it. But when the Figures be odd then the middle between 1 at the left end and the Number is the Square Root of the Number. Thus the Square Root of 1764 is 42, and the Square Root of 256 conſiſting of odd Figures is 16, the the left hand 1 being the Unite.

20. The Cube Root of a Number is the firſt of two mean proportionals between 1 and the number propounded, found by dividing the Space between them, on the Line of Numbers into three equal parts, on Lines of continued Radiuſſes.

But to find how many Figures muſt be in the Root, and alſo the right Unites in Lines of two Radiuſſes, ſet points under the firſt Figure, the fourth, the ſeventh, and tenth Figure, beginning at the left hand: and ſo many points as the Cube Number hath, ſo many Figures the Root contains as Integers.

Alſo

Alſo if the laſt point falls on the laſt Figure, as in 4096. then the left hand 1 at the middle or beginning is Unite, and the Unite Root Cube all in one Radius, *viz.* 16. But if it falls on the laſt but one, as in 85184, then the 1 at the beginning is the only Unite; and the Cube will be in the other Radius, and the Unite and Root in the firſt Radius, *viz.* 44. But if it falls on the laſt but two then the right hand 1.100 or 100 at the end is Unite; as in 274625. and the Unite and Root, *viz.* 65, and Cube are all in one Radius backwards.

CHAP. VII.

Of the Uſe of the Line of Numbers in Meaſuring of Timber, or any Solid Meaſure—Round or Square.

1. THE mean proportion or middle between the breadth and thickneſs, counted and meaſured with Compaſſes on the Line of Numbers, is the ſide of a ſquare equal to that breadth and thickneſs.

2. The extent from the Inches ſquare to 12, ſhall reach from 12 at twice turning the Compaſſes to the Inches long to make a Foot Solid.

3. Or the extent from 12 to the breadth in Inches, ſhall reach the ſame way from the depth in Inches to a fourth; then as the fourth to 12, ſo is 12 to the Inches long to make one Foot of Timber.

4. For ſmall Timber ſay, As 1 Foot to the breadth in Inches, ſo is the depth in Inches to a fourth, then as that fourth to 12 ſo is 12 to the Feet long to make a Foot.

5. As 12 to the Inches ſquare, ſo is 12 twice repeated to the Inches in one Foot long, (of which 12 makes one Foot.)

6. Or as 12 to the breadth in Inches, ſo is the depth in Inches to the Inches contained in one Foot long, of which Inches 12 makes one Foot.

7. As 12 to the Inches ſquare, ſo is the length in Feet twice to the content in Solid Feet.

8. As

8. As 12 to the breadth in Inches, ſo is the depth in Inches to a fourth, then as 12 to that fourth ſo is the length in Feet to the content in Feet: But uſing Foot-Meaſure, uſe the point of 1 inſtead of 12.

Diamieter.

9. As the Diameter in Inches to 13.54 (the Diameter when 1 Foot long makes 1 Foot of Timber) ſo is 12 twice to the length in Inches to make one Foot.

10. As 13.54 to the Diameter in Foot Meaſure, ſo is 1 twice to the Feet and 100 Parts in a Foot long, or ſo is 12 twice to the Inches and 100 Parts in a Foot long.

11. As 13.54 to the Diameter in Inches, ſo is the length in Feet twice to the content in Feet (in Foot Meaſure uſe 1.128) but if you count $\frac{1}{4}$ of the Girt the ſide of the ſquare, for 13.54 uſe 15.26.

Circumference.

12. As the Circumference in Inches to 147.36 (the Inches about, when 1 Inch long makes 1 Foot) ſo is 1 twice to the Inches long to make 1 Foot.

13. Or, As the Circumference in Inches, to 42,54 (the Inches about, when 12 Inches long makes 1 Foot:) so is 12 twice to the Inches long to make 1 Foot, or so is 1 twice to the Feet in length to make 1 Foot of Timber.

14. As 42,54 to the Inches about, so is 12 twice to the Inches contained in 1 Foot long, or so is that extent laid twice the same way from 1, to the Feet in one Foot long.

15. As 42,54 to the Inches about, so is the length in Feet twice repeated the same way, to the content in Feet.

But if you count a fourth part of the Girt, as the side of the square equal, then instead of 42,54; use 48 as a Center to work from.

Of Cones.

16. As 1 to the Area of the Base of any Cone in Inches, so is one third part of the Altitude in Inches to the solidity of the Cone in Cube Inches.

17. Or

17. Or thus, As 1.128 to the Diameter at the Base in Inches, so is one third of the Altitude in Inches, twice repeated, to the content in Inches.

Of a Globe.

18. As 1 to the Diameter in Inches, so is the Circumference in Inches to the superficial content round the Globe in Inches.

19. Or, As 10 to the Diameter in Feet and Parts, so is 31.416 to the superficial content round about the Globe in like parts to the Diameter.

20. As 1 to the Diameter in Inches and Parts, so is that extent twice repeated from the Diameter to the Cube of the Diameter; then as 21 to 11, so is the Cube of the Diameter to the Solid Content of the Globe in like parts.

21. Or the extent from 10 to any other Diameter, being thrice repeated the same way from 523.60 (the Solid Content of a Globe whose Diameter is 10) gives the Solid Content in like parts to the Diameter.

22. The

22. The extent from 1 to 1.90986 (the Arithmetical Complement of 523.5987) ſhall reach from the ſolid Content in Inches to the Cube of the Diameter, whoſe Cube Root is the Diameter.

23. As 1 to the Segments Diameter in Inches (of a Globe) ſo is the Segments half Altitude, twice repeated, to the near ſolid Content in Inches.

24. As 1 to the Globes Circumference, ſo is the Segments Altitude to the Segments Superficial Content of the round part.

25. As the Gauge Point 18.95 for Ale, or 17.15 for Wine Gallons, to the Globes Diameter in Inches, ſo is 2 third parts of the Diameter in Inches, to the Content in like Gallons to the Gauge Point uſed.

CHAP.

CHAP. VIII.

The Use of the Line of Numbers in measuring Bricklayers Work.

1. AS 1 to the length in Feet of any Foundation, so is the breadth in Feet to the Superficial Content in Feet.

Secondly, As 1 to the Superficial Feet, so is the depth in Feet, to the solid Content in Feet.

Thirdly, As 27 the solid Feet contained in 1 Yard (or Load) to 1, so is the solid Content in Feet, to the Content in solid Yards or Loads.

2. Or thus at two Operations, As 9 to the length in Feet, so is the breadth in Feet, to the Content in Superficial Yards: Then,

As 3 Foot the depth of one Yard, to the Content in superficial Yards, so is the depth in Feet, to the content in Solid Yards.

3. *Note,*

3. *Note*, That 272 Foot, 3 Inches is 1 Rod of Brick-work, at 14 Inches or 1 Brick and a half thick, and the Center Point for it, is at 1.

And all other thicknesses are to be reduced to a brick and half thick, and the Centers for all other thicknesses are thus found:

As half a Brick at 05, or as one Brick at 1, two Bricks at 2, two and a half at 2 5, three Bricks at 3 0, is to 1 5 the Center for 1 Brick, so is 1 the Center for a Brick and a half thick, to 3 the Center for half a Brick, or to 075 the Center for two Bricks, or to 06 the Center for two Bricks and half, or to 05 the Center for three Bricks, and so for any other thickness, as for 5 Bricks thick the extent from 5 to 1 5, the Center for 1 Brick, shall reach the same way from 1 the Center for one Brick and a half, to 03 the Center for five Bricks.

4. The extent from the Center Point for any thickness, to the length of any Wall, shall reach the same way from the breadth of the Wall to the Solid Content in Feet, reduced to a Brick and a half thick.

5. The extent from 3 for three half Bricks thick, to 1, 2, 4, 5, 6, 7, or 8 half Bricks thick, will

will reduce any Sum from any Number of half Bricks thick, to three half Bricks thick (which is one Brick and a half) thus 272 Foot at 5 half Bricks thick, is 4536 Foot at a Brick and a half thick.

6. The extent from $272\frac{1}{4}$, to 1 shall reach the same way from any Number of Feet, to the Rods, and Quarters, and Decimals over; and the same extent laid the contrary way from the Decimals over, reduces them to Feet. Thus in 5286 Feet is 19 Rod one quarter and 46 Foot.

7. The extent from $272\frac{1}{4}$ the Number of Feet in one Rod, to the price of one Rod, shall reach the same way from the whole Number of Feet, to the whole price. *Example*, 5286 Foot at 5 *l.* 5 *s.* *per* Rod, will come to 97 *l.* 1 *s.* 11 *d.* 2 *f.*

Or having cast up what the even Rods and Quarters come to, the same extent from $272\frac{1}{4}$ to the price of $272\frac{1}{4}$ Foot, will give the exact Answer what the odd remaining Feet comes to, which added to the price of the Rods and Quarters, makes up the whole price required.

8. The

8. The extent from 0666, to the breadth of any Roof, ſhall reach the ſame way from the length of the ſame Roof, to the Squares and Feet over, for both ſides of the Roof as flat and half flat.

Which Rule ſerves both for the Carpenter for his Rooffing, and for the Brick-layer for Tiling, due Conſideration being had in taking the Dimenſions for each of them.

CHAP. IX.

The Uſe of the Line in ſimple and compound Intereſt.

1. THe extent from 100, to the Intereſt due for 100 *l.* in one Year, ſhall reach the ſame way from any other Sum to his proportional Intereſt in one Years time; thus as 100 to 6, ſo is 45 *l.* to 2 *l.* 14 *s.*

2. For Months, count thus, If 6 be 12 Months or one Year, then 5 is 10 Months, 4 is 8 Months, 3.5 is 7 Months, *&c.* leſs than 1 Year, ſo alſo 7 is 14 Months, 12 is 24 Months

24 Months or 2 Year, 18 is 36 Months or 3 Year, *&c.*

Then thus, for finding the Intereſt of any Sum any Number of Months, ſuppoſe 15 Months, the half of 15 is 7.5, then as 100 to 75, ſo is any other Sum, as ſuppoſe 45 *l.* to his Intereſt in 15 Months, *viz.* 3 *l.* 7 *s.* 6 *d.*

3. For Days, by the Printed Paper, the extent from 100 to any Number of Days there expreſt, ſhall reach the ſame way from any other Sum, to the Intereſt thereof in ſo many Days, as ſuppoſe 15 *l.* for 90 days at 6 *per Cent.* the extent from 100 to 90 days, ſhall reach the ſame way from 15 *l.* to 4 *s.* 5 *d.* 1 *far.* near the exact Intereſt of 15 *l.* in 90 days.

Otherwiſe (by or) without the Paper Print thus, as 365 to to the rate of Intereſt, ſo is the Number of days to a fourth, being the Intereſt of 100 *l.* in ſo many days; then as 100 to that fourth, ſo is the Sum propounded to the Intereſt due for that Sum, in ſo many days.

4. For principal, and increaſe, or preſent worth, thus: Note 106 is the increaſe

and

and principal in one Year at 6 *per Cent.* 112 is 2 Year, 118 is 3 Year, thus every Tenth is 2 Months, and every half Tenth on the Line count for 1 Month. *Example*, What is the increase or present worth of 125 *l.* in 40 Months, the half of 40 is 20, to which add 100, is 120: then the extent from 100 to 120, the principal and increase of 100 *l.* in 40 Months shall reach the same way increasing from 125 *l.* to 150 the increase in 40 Months, and the same extent laid the contrary way decreasing from 125 gives 104 *l.* 4 *s.* the present worth being due 40 Months to come.

5. Of Equation of Payments, in brief thus.

As the Sum of the present worths to pay presently, to the Sum of the payments to be paid in time, so is 1 to 4th Number, from which taking 100 remains the Interest of 1 *l.* for the time sought, which Interest divided by 0001643 8, the Quotient is the Answer.

Example.

If 220 *l.* to be due at a Years end, the present worth is 207 *l.* 11 *s.* 6 *d.* for as 106 to 100, so is 220 to 207 *l.* 11 *s.* 6 *d.* But if it should be paid at 55 *l. per* Quarter, when

when ſhould it be paid at once, to be equal between Debtor and Creditor? Say

As { 101.5 for 3 / 103. for 6 / 104.5 for 9 / 106. for 12 } Months { to 100 }

ſo is 55 *l.* to { 54 20 / 53 41 / 52 63 / 51 90 } the preſent worths of 55 *l.* due at { 3 / 6 / 9 / 12 } Months.

The Sum 212 14 of all the preſent worths.

Then as 212 *l.* 14 the Sum of the preſent worths to 220 the Sum of the Payments at at 55 *l.* *per* Quarter, ſo is 1 to 103.70, from which taking 100 reſt 03.70; then the extent from 000164.38 to 1, ſhall reach from 0370 to 225 the true Number of days to pay the 220 *l.* at once: for the Intereſt of 220 *l.* in 225 days comes to 8 *l.* 5 *s.*

Of Compound Intereſt.

6. Any Sum of Money put out for any time at any rate of Intereſt, to receive at the Expiration of the time Compound Intereſt, to find the increaſe and principal, ſay thus, for years only.

As 100 to the principal and increase of 100 *l.* in one Year, so is the Sum propounded to the principal and increase in one Year, at once repeating of the Compasses, in two Years at twice, in three Years at thrice, *&c.*

Example, What is the increase and principal of 36 *l.* 10 *s.* at the end of 4 Years at 6 *per Cent.* Compound Interest, the extent from 100 to 106 being four times repeated, increasing from 36 *l.* 10 *s.* shall reach to 46 *l.* 2 *s.* the principal and increase in 4 Years time at 6 *per Cent.*

And the same extent four times repeated from 36 *l.* 10 *s.* decreasing, shall reach to 28 *l.* 18 *s.* the present worth of 36 *l.* 10 *s.* being due to be paid at the end of 4 Years to come.

Also Note, If 106 is for 12 Months, 103 is for 6 Months, 1015 for 3 Months, *&c.* as before.

7. To perform the same when many Years, Months, and Days are propounded; make use of a Scale of equal parts equal to the Radius of the Line of Numbers, then from this Table compute the Logarithmes of the Years

Years, the Months and Days in one Sum, and that extent taken from that Scale, and laid increasing or decreasing from the Sum propounded on the Line of Numbers, shall give the increase or present worth required.

da	Logar. days	Log. Months	Log. Years	Ye.
1	00006928	00210882	02530586	1
2	00013857	00421764	05061173	2
3	00020786	00632646	05791759	3
4	00027713	00843528	10122346	4
5	00034642	01054411	12652932	5
6	00041571	01265293	15183519	6
7	00048498	01476716	17714105	7
8	00055431	01687057	20244692	8
9	00062360	01897993	22775279	9
10	00069281	02108822	25305865	10
11	00076215	02319704	27836452	11
12	00083141	02530586	30367038	12

Example, If 54 *l.* 10 *s.* be put out for 6 Year, 8 Months and 11 Days, What the increase or present worth?

The Log. of 10 Years is	25305865
The Log. of 6 Years is	15183519
The Log. of 8 Months is	01687057
The Log. of 10 Days is	00069281
The Log. of 8 Days is	00055431
The Sum of the Log.	42301153

Being the Logarithme of 16 Year, 8 Months, and 18 Days.

Then this extent 423011 taken from the Scale of equal parts, and laid increasing from 54 *l.* 10 *s.* gives 144 *l.* 4 *s.* for the principal and increase in 16 Years, 8 Months and 18 Days.

Or if the same extent be laid decreasing the contrary way, it will reach to 20 12 *s.* the present worth of 54 *l.* 10 *s.* due 16 Years, 8 Months, and 18 Days to come at 6 *per Cent.*

8. To find the Increase or present worth Annuities.

First, Find what Sum of Money it is whose Interest yearly, is equal to the Rent Annuity yearly, or quarterly, or half yearly

The

Then by the laſt Rule find the increaſe at the time propounded, and from that Sum take the firſt found principal, and the remainder is the increaſe required.

Example.

If an Annuity of 10 *l. per An.* to continue 21 Years, what is the increaſe at 21 Years end, or the preſent worth to buy it to gain at 6 *per Cent?*

Firſt ſay, As 6 to 100, ſo is 10 to 166: 666 for a principal, whoſe Intereſt is 10 *l. per An.*

Then the Logarithme of 1 Year at 6 *per Cent.* multiplied by 21 is 5314232, which taken from the Line of equal parts, and laid increaſing from 166.666, gives 566666 for the principal and increaſe of Arrears in 21 Years, from which taking 166.666 remains 400 the increaſe.

Or the ſame extent laid decreaſing from 400, gives 117 *l.* 12 *s.* the preſent worth of 10 *l. per An.* for 21 Years, to gain at 6 *l. per Cent.* for other Rates make other Tables of Logarithmes.

CHAP. X.

The Use of the 30 and 40 Scales.

THe Scale of 30 is 11 Inches 3 quarters (or more or less) divided equally into 30 Foot, and every of those Feet into 10 or 12 parts, for Decimals, or Inches.

The Scale to 30 is drawn on both Leggs (to use Sector wise) from the Center in the middle of the Head, and may be used as a general Scale in Architecture. The 40 Scale is equal in length to it, and next to it.

In small Draughts, let every Foot represent a Model, then every Inch is five Minutes.

In mean Draughts the whole Scale to 30 may represent 3 Models, then every Foot is 6 Minutes, and every Inch half a Minute.

In

In great Draughts let 30 Foot represent half a Model, then every Foot is one Minute, and every Inch one 12*th* part of a Minute.

In using of the 30 Scales, or any such like a Sector; four Terms for brevity sake are used and thus explained, and Characterized,

1. Lateral —, Parallel =, nearest Distance N. D. and Common Line.

Lateral or —, is any Distance or Extent taken along any Line, from the beginning thereof to any Feet and Inches, Degree or Minute of a Degree on one Line only.

2. Parallel or =, is any Extent taken across from a Line on one Leg, to the same Line and Mark on the other Leg, as from 15 Foot on one Leg to 15 Foot on the other Leg in the 30 Scales.

3. *Note* also, That in all Parallel Extents you must set the Compass Points in that Line only which runs up to the Center of the Head, in which Line the Brass Center Pins are put, as at 15, which Line is some-

time common to Two Lines, as Sines and Lines, or Sines and Tangents, and therefore is it called the Common Line.

4. Neareſt Diſtance (in ſhort written thus N. D.) is the Neareſt Diſtance from any Point in one Line to another Line, or to the Thred pulled ſtrait in finding the Hour or Azimuth, which is found or diſcovered by keeping one Point fixed in the given Point, and turning the other Foot about toward the Line or Thred till it will but juſt touch, or as it were cleave it in ſunder.

Uſe 1. Any Line given and called any Number of parts, to add to it, or take from it, any parts in proportion.

Example, Let 8 Inches be called 15 Foot and I would have 10, or 20 Foot, to the ſame Proportion.

Take 8 Inches between your Compaſſes, and make it a = Parellel in 15 and 15, on the 30 Scales, then the = extent between 10 and 10, ſhall be 10 Foot, part of the 15 Foot, and the = extent between 20 and 20, ſhall be 20 Foot, being more than 8 Inches, the firſt 15.

2. To

2. To divide a Line into any Number of of Parts.

Take the given Line between your Compasses, and make it a = in the parts you would have it divided into, on the 30 Scales: then the = extent between 1 and 1 in the Common Line exactly taken, shall divide the Line into the parts required.

Example, Let 6 Inches be a Line to be divided into 9 parts, take 6 Inches between your Compasses; make it a = extent in 9, and in the Common Line of the 30 Scales, then take out = 1 and 1 from the same 30 Scales, and it shall divide the Line into 9 parts.

Or if you make the Line given, a = extent in 27, which is 3 times 9, then take out = 3 instead of = 1, and that shall do it better.

3. To lay down, or draw a Line to represent any Number of Feet and Inches required.

Take the Number given from any Scale of equal parts, and that shall be a Line so required, to that Scale.

But

But if the Scale you uſe be too great or too ſmall, you may uſe the 30 Scales parallelly. *Example*, Suppoſe I would have 4 Inches repreſent 30 Foot, take 4 Inches between your Compaſſes, and make it a = in 30 and 30, and then the 30 Scales will anſwer your deſire.

4. Any 2 Lines given to find their proportion one to another.

Take the Lines ſeverally between your Compaſſes and lay them laterally from the Center on the 30 or 40 Scales, and the Numbers in which they ſhall terminate, ſhall be their proportion one to another.

But if the one Line be called by any certain number of parts, then do thus.

As Suppoſe a Line of 5 Inches long be called 10 Foot, then what ſhall I call a Line of 8 Inches?

Make 5 Inches a = in 10 and 10, then take 8 Inches between your Compaſſes, and carry them = ly, till the Compaſs Points ſtay in like parts on both Leggs in the Common Line, which will only be in 16 and 16;

16; therefore those Lines of 5 and 8 are in proportion as 14 to 16.

5. Any two given, to find a third in continual *Geometrical Proportion* to them, either increasing or decreasing.

Lay both Lines laterally on both Leggs, and Note where they end, and when you increase take the greatest — Line and make it a = in the terms of the least, then the = Terms of the greatest, gives the — third Term, in continual *Proportion Geometrical.*

But if you would decrease, then fit the Lateral lesser Term in the = greater Term, then the = Terms of the lesser Term shall give a Lateral lesser Term in Proportion required.

As by the Line of Numbers thus, The Extent from 2 to 4 reaches the same way increasing from 4 to 8.

Or contrary, decreasing the Extent from 8 to 4, reaches the same way from 4 to 2.

By the 30 Scales, as — 2 to = 4, so is — 4 to = 8, or decreasing, as — 8 to = 4, so is — 4 to = 2, the third Proportion required.

6. To

6. To find a mean Proportion *Geometrical* between two Lines or Numbers.

Of the two Numbers find the Sum by Addition, and the half Sum, the Difference between them, and the half Difference, by Subſtraction.

Then open the 30 Scales to a Right Angle, by making — 20 a = in 12 and 16 on the Common Line.

Then taking the — half Sum between your Compaſſes, and ſet one Point in the half Difference on the 30 Scale, and extending the other Point =ly toward the other 30 Scale, and in the Common Line it ſhall give the mean *Proportion Geometrical* required.

Example, Let a long Square have his ſides the one 12 Inches, and the other 9, what is the ſide of a Square equal to that long Square, or the Square Root of 108, which is 9 times 12; the Rectangle or Product of 12 multiplied by 9.

12 and 9 added makes 21 for a Sum, whoſe half Sum is $10\frac{1}{2}$, then 9 ſubſtracted from 12 remains 3 for a Difference, whoſe half Difference is $1\frac{1}{2}$. Then

Then the 30 Scales being Square, or at Right Angles, take — 10 $\frac{1}{2}$, between your Compasses, set one Point in 1 $\frac{1}{2}$, the half Difference, then extending the other Point to the other 30 Scale in the Common Line, it gives 10 Foot, 4 Inches, $\frac{2}{3}$, the Geometrical mean Proportion required. By the Line of Numbers the exact middle between 12 and 9 is 10.393.

7. To three Numbers given to find a fourth in *Geometrical Proportion*, or the *Rule of Three* Direct.

1. In the *Rule of Three* there is three Terms given, and a fourth required.

2. The fourth Term is in proportion to the third, as the second is to the first.

3. Of the three Terms, that of Demand is always the third Term, and the other of the same denomination is the first, then the remaining Term is the second.

4. If the Terms propounded be of various Denominations, then they ought to be reduced; that is, the third and first to one Denomination, and the second and fourth

to

to the ſame Denomsination, as low as you can.

5. Conſider whether your third Term requires more or leſs, if more, then multiply the third term by the greater of the two remaining Terms, and divide by the leſs. If leſs be required, multiply the third by the leaſt remaining Term, and divide by the greater.

6. By the Line of Numbers the work is thus, The extent from the firſt Terms to the ſecond, ſhall reach the ſame way from the third Term to the fourth.

But by the Line of Lines or equal parts, you will ſometimes want a leſſer Scale to begin the work, which is ſupplied by doubling your Scale, calling 10, 20; 20, 40, *&c.* or calling 10, 100; 20, 200; *&c.*

Example, If 16 Ounces coſt 2 *s.* what ſhall 30 Ounces coſt?

As

As — 16 calling 10 a 100
To = 2
So is — 30 from the ſame Scale
To = 3 ¾ the Anſwer.

Or thus by changing the Terms.
As—third 30 *Oun. from a leſs Scale*
To = firſt 16
So is = ſecond 2
To a — fourth 3¾ *on the ſame Scale.*

Or again, As — ſecond 2, to = firſt 16, So is = third 30, to — fourth 3 ¾, which is the beſt Anſwer literally given on the ſame Scale.

Or by the fourth Rule before, by reducing the 2 *s.* to 24 *d.* four ways.

1. As — 16 Ounces to = 24 Pence, ſo is — 30 Ounces to = 45 Pence.

2. As — 30 to = 16, ſo is = 24 Pence to — 45 Pence the Anſwer.

3. As — 24 to = 16, ſo is = 30 Ounces to — 45 Pence, as before.

4. As — 16 to = 30, ſo is — 24, to = 45 the Anſwer.

Thus

Thus you see that the Question may be wrought four ways, with two Answers Laterally, and two Parallelly, as you please, and by due Consideration you may see the reason of it.

8. To Measure any Superficies by the 30 Scales.

At any Inches broad, to find how many Inches in length makes 1 Foot.

Take — 12, make it a = in the breadth given, then take out = 12, and measure it — ly from the Center, and it shall reach to the length required to make one Foot Superficial.

Example, At 9 Inches broad as — 12 to = 9, so is = 12 to — 16.

The breadth given in Inches and the length in Feet, to find the Superficial Content in Feet and Inches.

Example, At 9 Inches broad and 15 Foot Inches long, to find the Content.

Take

Take — 15 Foot 3 Inches, make it a = in 12, then take out = 9, and it ſhall give — 11 Foot 5 Inches the ſuperficial Content.

9. To Meaſure Timber or Solid Meaſure, by the 30 Scales.

Example, At 8 Inches Square to find how much in length makes 1 Foot?

Take — 8 make it a = in 12, then take out = 8 and it gives — 5 $\frac{4}{12}$, then again as — 12 to = 5 $\frac{4}{12}$, ſo is = 12 to — 27 Inches the length, to make 1 Foot of Timber. Here you muſt uſe a leſs Scale to take 12 from.

But if the Piece is not Square, find the Square equal by the Sixth *Uſe*, or work it thus: *Example*, At 8 Inches thick, and 14 Inches broad,

As — 8 to = 12, So is = 14 to — 9 $\frac{6}{12}$ a Fourth, Again, as — 12 to = 9 $\frac{6}{12}$ the Fourth, So is = 12 to — 15 $\frac{6}{12}$ the Inches long to make 1 Foot.

10. The breadth and thickneſs given in Inches, and the length in Feet, to find the Content.

Example, At 8 Inches thick, and 14 Inches broad, and 18 Foot long,

As — 8 to = 12, ſo is = 14 to $9\frac{4}{12}$; Again, as — $9\frac{4}{12}$ to = 12, ſo is = 18 the length to 14 Foot the ſolid Content in Feet.

But having the ſide of the Square in Inches, and the length in Feet, work thus:

(The Square equal between 8 and 14, is $10\frac{7}{12}$. Then:)

As — $10\frac{7}{12}$ to = 12, ſo is = 18 the length to $15\frac{10}{11}$ a Fourth. Again

As — $15\frac{10}{11}$ to = 12, ſo is = $10\frac{7}{12}$ the ſide of the Square to 14 Foot the ſolid Content in Timber Meaſure.

11. The breadth of any Frame given, and the perpendicular height of the Gable end, to find the Rafter, and Hips length, and the Angles at Foot and Top, with the Hips out-ſide Angle, by the 30 Scales.

Example. Let the breadth of the Frame or raising Piece be 24 Foot, and the perpendicular 13 Foot 6 Inches.

1. Open the Rule, or rather the two common Lines of the 30 Scales to a Right Angle, by making — 20 a = in 12 and 16 on the 30 Scales. Then

For the Rafters Length.

1. The = Extent from 12 the half breadth to 13 Foot 6 Inches the perpendicular, shall be the — Extent from the Center to 18 Foot the length of the Rafter.

Also a Rule laid to those Two Points 12 and 18, and a Bevel set to it, and the common Line on the 30 Scales, at each Leg shall give the Angles at Foot and Top.

For the Diagonal.

2. The ⊏ Extent from 12 on one Leg, to 12 on the other Leg on the 30 Scales, shall give the — length of the Diagonal Line, viz. from the Corner to the King Post 17 Foot.

For the Hip.

3. The — Extent from 17 Foot on one 30 Scales, to 13 Foot 6 Inches the perpendicular on the other 30 Scale, measured laterally from the Center, gives 21 Foot 8 Inches the Hip, Rafter, or Sleeper.

Also a Rule laid to 17 on one Leg, to 13,6 on the other, in the Common Line: and a Bevel applied to the Rule so laid, and each 30 Scale gives the Angles at Foot and King Post.

Neareſt Diſtance.

4. To find the Neareſt Diſtance from one Corner of the Frame to the Hip Rafter ſet up in its place on the other Corner.

Count the Hips length on the 30 Scales, and take that — Extent between your Compaſſes, then ſet one Point in the breadth of the Frame, and cloſe the 30 Scales till the other Foot touches the Hips length in the Common Line of the other 30 Scale.

Then the 30 Scales being ſo ſet, the Neareſt Diſtance from the breadth of the Frame 24 Foot, counted on one 30 Scale to the Common Line, on the other 30 Scale is — 20 Foot the Neareſt Diſtance required from the corner of the Frame to the oppoſite Hip ſet up.

Hips Outer Angle.

Laſtly, Take out the half Diagonal Line, *viz.* 17 Foot from the Center — by, and make it 2 — in half the Neareſt Diſtance laſt found, *viz.* 10 and 10 in each Leg, then

is the 30 Scales set to the Mould or Angle of the back of the Hip Rafter.

Here you use the half Diagonal, because the whole exceeds 30 the length of the Rule or the whole 30 Scales, otherwise use the whole Diagonal and whole ND.

To find the quantity of this Angle; just as the Rule stands take the = Extent from 15 and 15 on the 30 Scales, and measure it on the Line of Chords from the Center, and it gives 116 degrees, the quantity of the out-side of the Hip Rafter.

12. To find the Rafters and Hips length in Bevelling Frames.

For the Rafters Length.

1. Set the 30 Scales to a Right Angle as before, then count half the length of the Bevel end on one 30 Scale, and the perpendicular on the other 30 Scale, the = Extent between them shall be the true length of the Rafters for the Bevel end.

The Angles at Foot and Head are found by laying a Rule and scoring a Bevel as before.

Hips Length.

To find the Hips Length, set the 30 Scales on the Rule to the Angle of the Frame at each Corner, the one being more than a Square or 90 Degrees; and the other less. Then the = Extent from the half length of the Bevel End counted on each Leg, shall be half the Diagonal Lines, fit for each Corner; then with half the Diagonal Line and the whole perpendicular find the Hips Length as before.

Nearest Distance.

To find the Neatest Distance, do as before to set the Rule. The Length of the Hip, and the Length of the Bevel End made a = , but when you take the Nearest Distance, you must add half the Number of Feet and Inches belonging to the Neareſt Distance over in one or shortest Hips, and take so much less than the Nearest Distance over in the other or longest Hip, which always hath the least Angle on the outside of the Hip. The shortest Diagonal Line belonging to the longest Hip over the — Diagonal made a = in each Nearest Distance, sets the Rule to the Angle on the back of each Hip, one after another.

13. The Rafters Length and Perpendicular for Square Frames, and true Pitch, or *London* Roof, are found by Inſpection thus:

Seek the breadth of the Frame on the 40 Scales, and juſt againſt it on the 30 Scales, is the Rafters length required.

Then ſeek the Rafters length on the 40 Scales, and right againſt on the 30 Scales is the perpendicular required (near.)

A Table of the Length of the Rafter and Hips in Square Frames.

Rafter	15 —	00
Hip or Sleeper	18 —	00
Perpendicular	11 —	18
Breadth of Frame	20 —	00
Half Breadth	10 —	00
Diagonal	28 —	281
½ Diagonal	14 —	14
Neareſt Diſtance	16 —	624

		g.	m.
Rafter Angles	Top	41.	50
	Foot	48.	10

		g.	m.
Hips Angles	Top	51.	38
	Foot	38.	22

Difference 13.16

Top Twice	51.	38
	51.	38

Outside Angle 116.12

Note, That the Angle at Foot and Top is the same in all Square Frames, but the Lengths vary according to the breadth of the House, and having this Table for a House of 20 Foot wide, you may find it for any Length by the Line of Numbers thus:

As 20 Foot to any other width, so is any Length belonging to 20 to the Rafter or Hips Length at the given width required.

Example.

As 20 to 16, so is 15 to 12 the Rafter, so is 11.18 to 8.95 the Perpendicular, so is 18 to 14.40 the Hip, so is 14.14 to 11.35

the

the half Diagonal. So is 16.624 to 13.30 the Neareſt Diſtance.

For the Angles in general thus by Sines and Tangents, and Numbers.

1. As 15 the Rafters Length on Numbers, to the Sine of 90, ſo is 10 the half Width on Numbers, to 41.50 the Angle at the Top; the ſame Extent alſo ſhall reach from 11.18 the Perpendicular, to the Sine of 48.10 the Angle at Foot.

2. Again, As 18 the Hips Length counted on Numbers to the Sine of 90, ſo is 11.18 the Perpendicular height, counted on Numbers, to 38.22 on the Line of Sines the Angle at the top: And the ſame Extent ſhall reach from 14.14 the half Diagonal on Numbers, to 51.38 on the Line of Sines the Angle at the Foot of the Hip Rafter.

3. The Extent on Numbers from the Neareſt Diſtance from the Corner to the oppoſite Hip ſet up 16.624 to the Sine of 90, the ſame Extent laid from the Perpendicular Altitude 11.18 counted on Numbers ſhall reach to 42.14 the Penthouſe Boards Angle at the Foot; and from half the Diagonal Line 14.14 to 58.14 on the Sines, being half the Angle on the back of the Hip. Or

Or else thus by the Numbers and Tangents. The Extent on Numbers from the Perpendicular Altitude 11.18 to 18.0 the Hips Length counted on Numbers, shall reach the same way from the Tangent of 45 increasing to the Tangent of 58.14.

To work this by the 30 Scales and Tangents thus:

As — Tangent of 45, to = 11.18 on the 30 Scales, so is = 18 the Hips Length, to — Tangent of 58.14 as before.

Note, The Line of Chords is a Line of Natural Sines, calling the Chord 60, the Sine 30; and 90 of Chords, the Sine of 45; and the Chord of 180 the Sine of 90.

4. Also the Line of Chords serves to set the Rule to any Angle, or being set to find what Angle it standeth at, thus:

Measure from inside to inside just against 15, then that Extent laid from the Center Laterally, sheweth what Degrees the Rule standeth at. Or take any Lateral Chord, make it a Parallel from inside to inside just against 15, and the Rule is set to that Angle.

CHAP.

CHAP. XI.

The Use of the Quadrant Side.

1. *To set the Rule to an Angle of 60 Degrees.*

OPen the Rule till the Lines on the moving Leg make a right Line with the like Marginal Lines drawn on the Head (which otherwise seems broken) then is the Rule set to 60 Degrees. *Note* also, That some Rules are made to an Angle of 45 Degrees, the Wood being 18 Inches when opened, and a Brass Tongue added, of 6 Inches long, to make it 24 Inches, then the Brass Tongue being always ready, that serves to set the Rule to an Angle of 45 Degrees. Also, If you have a Third Piece, with Two Tennons at each end, to put into the Two Mortice Holes, at the inside Ends of the Two Legs of the Rule; then when they are put in, and pulled close, then is the Rule set exactly to an Angle of 60 degrees. But if you have no loose piece to put in, then you may set it exactly to 60 Degrees thus with Compasses.

Take

Take the — Lateral Extent from the Rectifying Point (being a Point in the meeting or crossing of the Lines on the Head, near to, or upon the Brass Revit in the head) to the Center on the Head Leg, where the Thred is fastened. Make the same Extent a Lateral Extent from the same Rectifying Point, to the Common Line for the Hour and Azimuth on the moving Leg, and there keep that Point of the Compasses fixed (and the Compasses at that Extent) open or shut the Rule till the other Point reaches exactly, just to the Center Hole where the Thred is; Then is the two Legs set to an Angle of 60 Degrees, and to keep it so, thrust a small Pin, into the lower Hole drilled quite through the Head, and that shall stay it there.

2. *To draw a Level Line, or to try if any Board or Poast is set Level.*

Hang a Plummet on the Nipple of the Thred, and apply the moving Leg to the Superficies of the Board or Stone to be set level, and if the Thred cuts or plays directly over the stroke at 60.0 on the moving Leg, then you may conclude that Plane to be exactly level, when by trying it every way you find it to play always on 60.0. Alſo

Also to draw a Horizontal Line on a Wall or upright Plane, apply a strait and parallel Rule to the Wall, having some body to hold one end of it, then apply the moving Leg to the Rule, and cause the Plummet to play on 60.0, then that Line drawn by the Rule first laid shall be a Horizontal Line (or a true Level Line.)

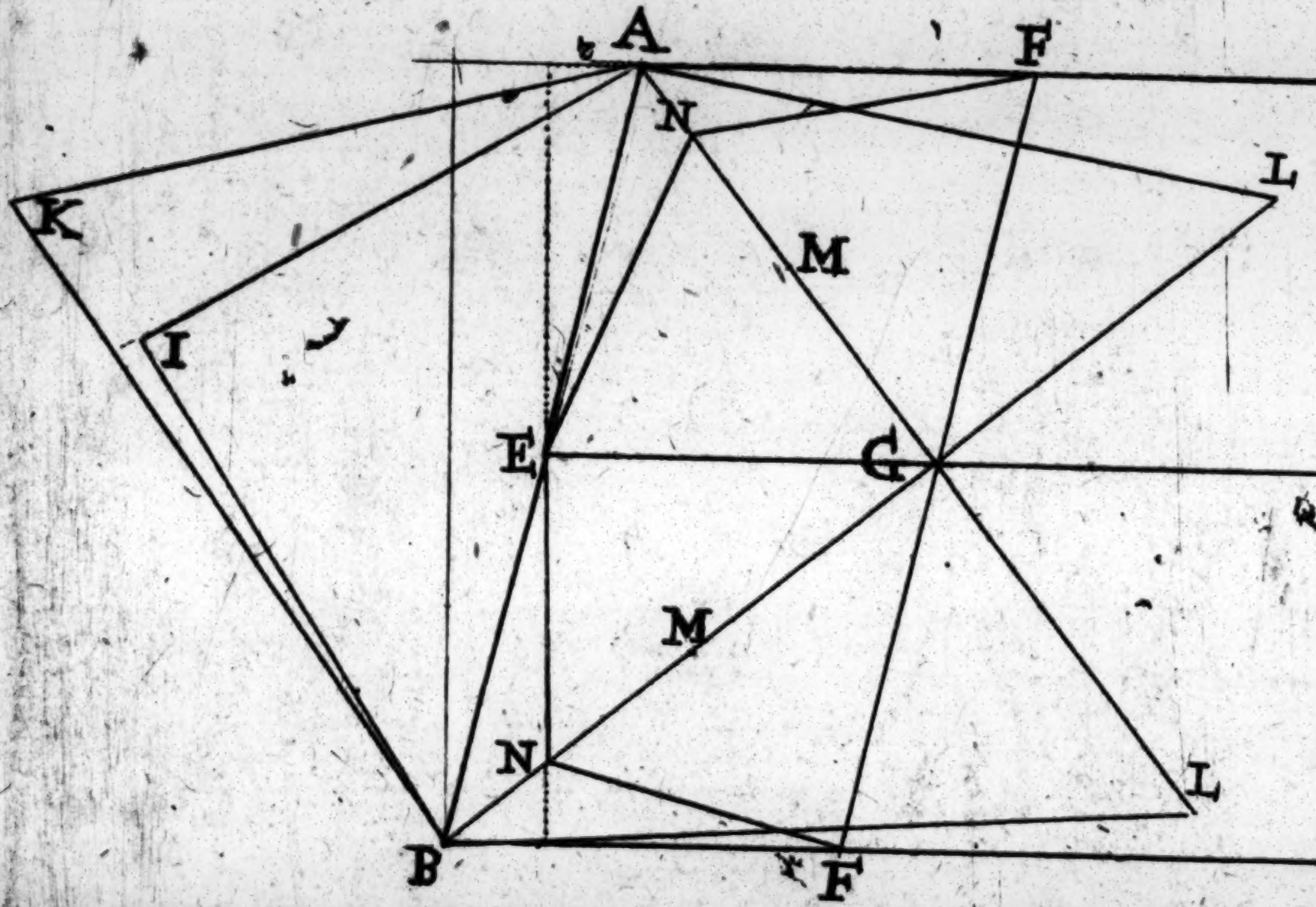
3. *To draw a Perpendicular Line on any Wall, or to try if any thing be upright or not.*

Hang a Plummet on the Noose of the Thred, then apply the Head Leg to the Wall or Post to be set upright, and if the Thred play right over the Rectifying Point or Stroke at 90 in the Degrees on the Head, then is the Plane or Post upright: and if you draw a Line along by the Head Leg of the Rule, it shall be a perpendicular Line.

4. *To find an Altitude by the Line of Degrees.*

First, Set the Rule to an Angle of 60 Degrees by *Use* the First, and fasten a *Plummet* to the end of the Thred.

Then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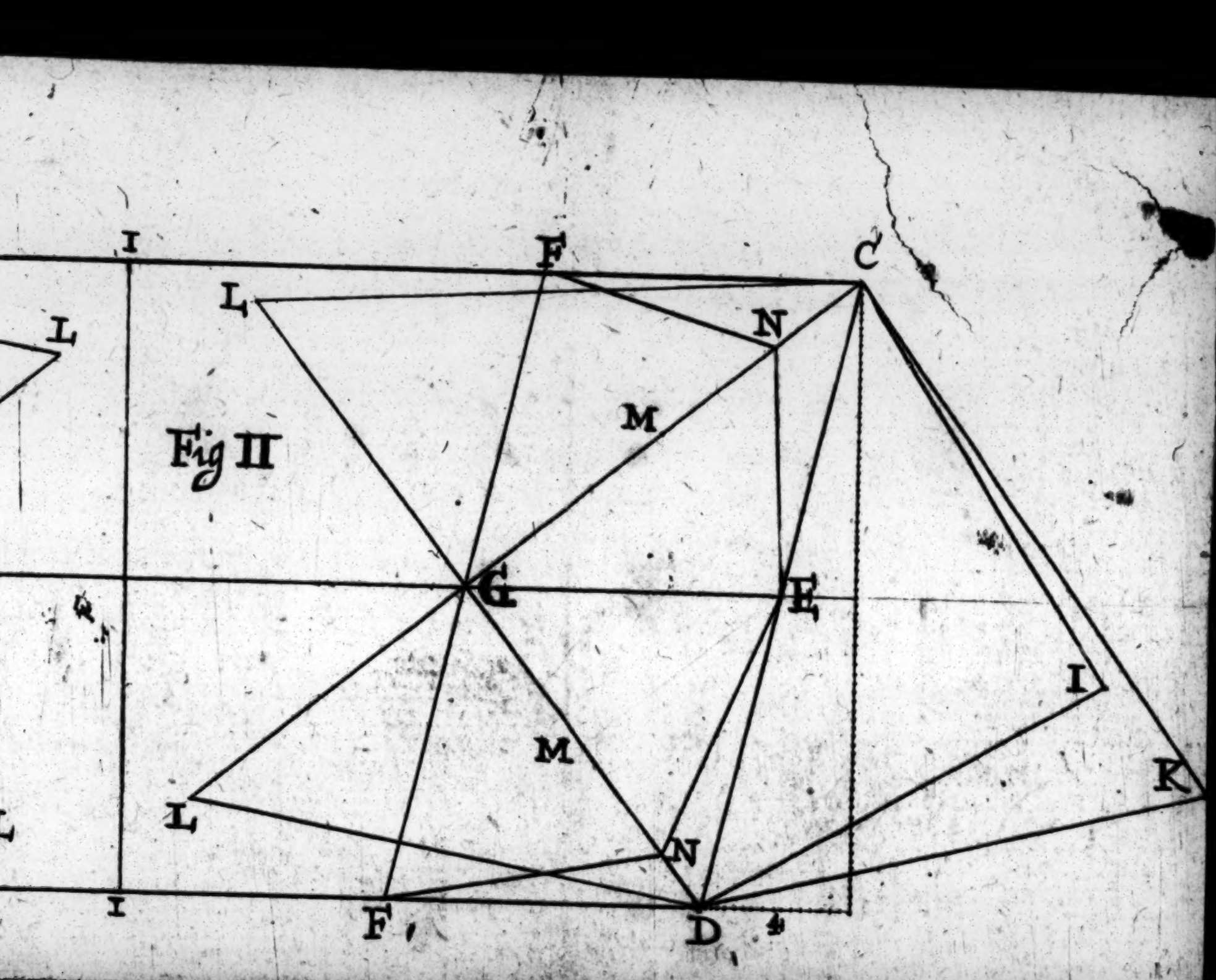

Fig II

Then look up to the Object, along or parallel to, the upper or lower Leg, according as the Object is high or low, then the Thred playing evenly, and steadily, along the moving Leg, shall on the Degrees shew the Altitude required.

Note, That if the Sun or Object you look at be low, *viz.* under 30 Degrees, then to look along the moving Leg is most convenient; then you must count from 60.0 on the moving Leg toward 30 at the Head.

But if the Altitude be above 30 Degrees, then look along the Head Leg to the Object, and then the greater Figures standing before the Lines, are to be used, beginning about 10, and ending at 90 at the Head.

Note also, That observing the Suns Altitude, when it shines bright, the Sun beams shining through a small Saw cut, in the ends of the loose piece, will cast a bright spot on the opposite part on the Head, to supply the want of sights, and to lean your Arm or Hand against some steady thing, will help you to be the more exact in this. And Note, That a heavy *Plummet* (is much better than (a light one) which will draw the Thred strait, and

and move to the least Variation more steadily. For Note, That the more exactly you find the Altitude, the truer shall you find the Hour, or the Suns Azimuth, or whatsoever depends thereupon.

5. *To find the Suns Rising, Setting, Declination or true Place, &c.*

Open the Rule to 60 Degrees, by putting in the loose Piece, or by the meeting of the Hour Line on the loose Piece and Head, or as before by Compasses. Then draw the Thred in the Center strait, and lay it over the day of the Month, then in the Line of Degrees it sheweth the Suns Declination, counting from 60.0 on the moving Leg, as the smaller Figures shew; if the Thred being laid over, the day of the Month falls on the right hand of 60.0, then the Suns Declination is Northward, but if it falls on the left hand of 60.0, the Declination is Southward, according to the time of the Year.

Also in the Hour Line, it sheweth the Suns Rising as you count the Morning Hours, or his Setting as you count in the Afternoon Hours; also in the Line of the Suns place, it sheweth his true place, and in the Line of

Right

Right Aſcenſion, his Right Aſcenſion. If you have thoſe Lines under the Months, or the beginning of every Sign, or every whole Hour of Right Aſcencion, among or over the Months, as it is ſometimes placed in narrow Rules for want of more room, then you may count every day, from that beginning for a Degree of the Suns place: Or every Day from the laſt whole Hour, for four Minutes of Time in the Suns Right Aſcenſion.

Example.

On the *Tenth* of *Auguſt*, the Thred drawn ſtrait, and laid over the *Tenth* of *Auguſt* in the Line of Degrees, cuts 12 Degrees and 20 Minutes of North Declination, alſo in the Hour Line it cuts 4.56 for the Suns Riſing, or 7.04 Minutes for his Setting, the Suns place that Day is in 28 Degrees of ♌ *Leo*, and his Right Aſcenſion is near 10 Hours, counting from *March* the 10*th*, as the Months do proceed.

6. *To find the Hour of the Day.*

Set the Rule to 60 Degrees, and find the Suns true Altitude, then with Compaſſes take it from the particular Scale of Altitudes, and lay the Thred to the Day of the Month,

and

and ſo keep it, then carrying one Point of the Compaſſes along in the Hour Line, till the other Point being turned about, will but juſt touch the Thred at the Neareſt Diſtance, then the Compaſs-Point fixed in the Hour Line, ſhall ſhew the Hour and Minute required, counting according to the Time of the Day.

Example.

Suppoſe on the 24*th of* Auguſt *the Suns Altitude is* 20 *Degrees.*

Take 20 Degrees from the particular Scale of Altitudes, *viz.* The Extent from the Center Pin at the beginning, to the long ſtroke at 20, between your Compaſſes; then laying the Thred over the Day of the Month, and putting one Point of the Compaſſes in the Hour Line, ſo as the other Point turned about will but juſt touch the Thred at the Neareſt Diſtance, then the Compaſs Points will ſhew 7.33 in the Forenoon, or 4.27 in the Afternoon of the ſame Day.

But in Winter time, as ſuppoſe on the 5th of *October*, at the ſame Suns Altitude you ſhall find the Hour to be 17 minutes after 9 *a. m.* or 43 minutes after 2 in the (*p. m.* or) Afternoon, in Latitude 51.32.

Note, That the contrary to this finds the Suns Altitude at any Hour of the Day any time of the Year, for if you lay the Thred to the Day of the Month or Declination, and then set the Point of the Compasses to the Hour Point in the Hour Line, and taking the N. D. from thence to the Thred, and measure it in the Particular Scale of Altitudes from the beginning, and it shall shew the Suns Altitude at that Hour and Minute.

7. *To find the Suns Azimuth or Point of the Compass he is in.*

Take the Suns Declination from the Particular Scale between your Compasses, and lay the Thred to the Suns Altitude, counted on the Degrees from 60.0 on the moving Leg toward the end, and sometimes beyond the end on the loose Piece; and so keep it, then in Summer time, set one Point of the Compasses on the right side of the Thred, in the Azimuth Line, so as the other Point turned about, will but just touch the Thred; then the Point of the Compasses fixed in the Azimuth Line, shall shew the Suns true Azimuth required.

Ex-

Example, At 20 Degrees of North Declination (or Summer time) and 30 Degrees of Altitude, you ſhall find the Suns Azimuth to be 84 d. 30 m. wanting of South in the Forenoon, or ſo much paſt the South in the Afternoon in 51.32.

But in Winter time, when the Suns Declination is Southward, *viz.* From 60.0 toward the South, or end of the Rule near 12, then you muſt carry the Compaſſes ſet on the left ſide of the Thred in the Azimuth Line: *Example*, At 10 Degrees of Declination, and 20 Degrees of Altitude, you ſhall find the Suns Azimuth to be 40 Degrees and 45 Minutes wanting of South in the Forenoon, or ſo much paſt South in the Afternoon.

Note, That when the Neareſt Diſtance falls without the Rule, you ſhould lay ſome thing as thick as the Rule, cloſe to the outſide of the Rule, and draw the Thred ſtrait over that, then may you find the exact place of the (Neareſt Diſtance) N. D. between the Compaſs Point and the Thred, the Thred laid over the Suns Altitude counted in the Degrees, and the Compaſs Point being fixed in the Suns Azimuth in the Azimuth Line.

Note, That on the 10th of *March*, and about the 12th of *September*, when the Sun hath no Declination, then there is nothing or no Extent to take between your Compasses. Then if you lay the Thred to the Suns true Altitude counted on the Degrees at the same time in the Azimuth Line, it cuts the Suns Azimuth at that Latitude and Altitude.

Example, In the Latitude of 51 Deg. and 32 Minutes, when the Thred is drawn strait over 38 and 28 in the Line of Degrees, it cuts the Center *Pin* for 0 Degrees of Azimuth, or the *Hour Point* of 12 in the Hour and Azimuth Line; at 30 Degrees high the Azimuth is 43 Deg. 15 Min. at 10 Deg. high the Thred cuts 77 Deg. 15 Min. of Azimuth, and at 0 degrees high at 60.0 the Thred cuts 90 in the Azimuth Line, rising then at due East and setting at due West.

8. *To find a Meridian Line at any time, the Sun shining.*

On any flat and level Superficies, as Table, or Tombe Stone, draw the Line made by the Shadow of a Thred and Plummet steadily held up.

Then

Then at the same time, or immediately after or before, find the Suns Altitude, and with that by the last Rule find the Suns true Azimuth.

Then in that Line drawn make a Center, and on that Center with 60 degrees of Chords draw an Ark of a Circle, and from that Shadow Line first drawn, lay off the Suns Azimuth last found the right way; as the time of the Day and the Suns motion considered, will certainly inform you which way: then a Line drawn from the Center to the point last made in the Arch, shall be the true (or very near) Meridian Line.

9. *To find the Latitude of any place, as City, Town, or Cape, &c.*

Just at Noon when the Suns Altitude is highest, find what it is by a true and careful Observation, and let it down, and take it from 90 by Substraction, then in Summer time add the Suns Declination to the remaining Number, and the Sum shall be the Latitude required.

But in Winter Substract the Suns Declination from the Number remaining, and the residue shall be the Latitude required.

Example, Suppose at *London* near the *Tower* on the 26th of *August* 1682, the Suns Meridian Altitude that day is 45 degrees and 10 minutes, which taken from 90 remains 44.50, the Suns Declination that Day and Year is 6.42, which added to 44.50 makes 51.32 or 33 the Latitude at *Aldgate*.

But if the Observation had been in the Winter, when the Declination had been Southward; as suppose on the 10th day of *November*, the Suns Meridian Altitude that day is at *London* 18.35, which taken from 90, remains 71.25, then the Suns Declination that day and Year is 19.53 South, which taken from 71.25; remains 51.32 the Latitude required.

This Rule serves every where between the Two Tropicks, but for small and great Latitudes there are many Cautions to be considered, which I will not now trouble the Reader withal, but refer them to the better consideration of them that shall have occasion to use it.

10. *To find the Hour of the Day in any Latitude between the Tropicks.*

To find the Hour universally by the General Scale of Sines, you are to find the Suns Altitude or Depression at 6, thus by the Sines and Degrees, with Thred and Compasses.

Count the Suns present Declination on the Degrees, from 90 at the Head toward the end, and thereon lay the Thred, then the N. D. from the Sine of the Latitude to the Thred, shall be the — Sine of the Suns Altitude at 6 above the Horizon in Summer, or his depression below the Horizon in Winter; by Sines and Tangents Artificially wrought thus, The Extent from Sine 90 to the Sine of the Latitude, shall reach the same way from the Sine of the Suns Declination to the Suns Altitude or Depression at 6, being briefly worded thus, As Sine 90, to Sine of the Latitude 51.32, so is the *Sine* of the Suns Declination 23.30, to the Sine of the Suns Altitude at 6, 18.12.

In *Summer time* take this Altitude at 6, out of the *Suns* present Altitude with Compasses on the general *Scale* of *Sines*, being

readily done thus: Having the N. D. from the *Sine* of Latitude to the Thred, in the firſt Operation, ſet one Point in the beginning of the Line of *Sines* at the Center, and turn the other downward, and note the place with a ſpot of Ink for all that Day. Then if you take the Extent from that noted place to any given Altitude all that Day with Compaſſes, you have the *Sine* of the *Suns* preſent Altitude, leſs by the *Sine* of the *Suns* Altitude at 6, or the *Sine* of the *Suns* Altitude at 6, leſs the *Sine* of the *Suns* preſent Altitude, when in the Morning or Evening before or after 6. This Extent call a reſidue or difference to be uſed in *Summer*.

But in Winter lay that N.D. or Depreſſion at 6 from the beginning of the Line of *Sines*, at the Thred and Center hole upward, and note that place with a ſpot of Ink for all that Day in Winter; then I ſay the Extent taken from that noted place, to the *Sine* of any Altitude all that day on the general *Sines*, ſhall be the *Sine* of the *Sum* of the *Suns* Altitude and Depreſſion at 6, to be uſed in Winter; and this Extent call a *Sum* of the *Suns* preſent Altitude and Depreſſion at 6, taken from *Sines* to be uſed in Winter.

Then

Then having this residue in *Summer*, or *Sum* in *Winter* between your Compasses, make it a = *Sine* of the Complement of the Latitude, lay the Thred to the N. D. then take out the = *Sine* of 90, then make that = Extent a = *Sine* in the Co-Declination, and lay the Thred to the N. D. and on the Degrees it shall shew the Hour from Noon as figured, counting 15 Degrees for an Hour, and every Degree 4 Minutes of Time, or the Hour from 6 counting from 90.

Example. In the Latitude of 51.32, the *Suns* Declination being 23 30, and the *Suns* present Altitude 10 Degrees, what is the Hour?

1. The Thred laid on 23 30, counting from 90, and the N. D. from the *Sine* of the Latitude 51.32 taken with Compasses, gives the — *Sine* of 18.12 for the *Suns* Altitude, or Depression at 6.

Then the *Sine* of 18 deg. 12 min. added to the *Sine* of 10 deg. the *Suns* present Altitude on the Line of *Natural Sines*, makes the *Sine* of 29 deg. 3 min. for a *Sum* to be used in *Winter*.

Or

Or the Sine of 10.0 the Suns present Altitude, taken from the Sine of 18.12 the Suns Altitude at 6, remains the Natural Sine of 7.58 Minutes for a Difference or Remainder to be used in Summer.

Then with this Lateral Difference in Sines, set one Point in the Sine of 38.28 the Colatitude, and lay the Thred to the N.D.

Then take the N. D. from Sine 90 to the Thred, then set one Point in the Sine of 66.30, the Co-sine of 23.30, the Declination (or 23.30 counting from 90 upward) and lay the Thred to the N. D. and on the Degrees it gives 56 Minutes before 6 in the Morning, or 4 Minutes after 5 in the Morning in Summer, or 56 Minutes after 6, or 4 Minutes before 7 at Night.

But at the same Altitude and Declination in Winter, you shall find the Hour to be 54 Minutes after 9 in the Forenoon, or 6 Minutes after 2 in the Afternoon.

Note, The whole Work may be briefly worded thus:

As

As the — Sine of the Sum or Difference of the Suns Altitude at 6, and his present Altitude in Winter or Summer, to the = Co-sine of the Latitude: So is the = Secant of the Suns Declination, made a = Sine of 90, and the Thred laid to N. D. on the Degrees, gives the Hour required.

To work the same by Sines and Tangents Artificial, briefly thus, At one Operation having found the Suns Altitude or Depression at 6, and the present Altitude, add the Natural Sines of them for a Sum in Winter, or substract the lesser from the greater (their Arks being found in a Table of Natural Sines) for a Difference in Summer, or use the Line of Natural Sines and Compasses as before. Then

As Co-sine of the Latitude, to the Secant of the Suns Declination, being as far beyond the Sine of 90, as the Co-sine of the Declination is short of 90: So is the Sine of this Difference or Sum first found, to the Sine of the Hour from 6.

11. *To find the Suns Azimuth in any Latitude.*

First find the Suns Altitude at East or West in Summer, or his Amplitude in Winter, thus by the general Sines, or Sines Artificial.

As the — Sine of the Suns Declination to the = Sine of the Latitude, laying the Thred to N. D. on the Degrees it gives the Suns Altitude at East or West required.

Again, *To find the Suns Amplitude by Sines and the Degrees.*

As the — Sine of the Suns Declination to the = Co-sine of the Latitude, so is the Sine of 90, by laying the Thred to the N.D. on the Degrees, it gives the *Suns* Amplitude that day at rising or setting.

By the Artificial *Sines* work both thus:

The Extent from the *Sine* of the Latitude, to the *Sine* of the Declination, being laid the same way from the *Sine* of 90, gives the *Sine* of the Vertical Altitude.

Or sometimes thus, As the *Sine* of the Latitude to the *Sine* of the Declination, so is the *Sine* of 90 to the *Secant* of the Vertical Altitude at East or West.

Again, For the Amplitude, thus by Logarithmal *Sines*.

As the Co-sine of the Latitude to the *Sine* of 90, so is the *Sine* of the *Suns* Declination, to the *Sine* of the *Suns* Amplitude at rising or setting.

1. *To find the Suns Azimuth, the Sun having no Declination, in any Latitude.*

Make the + Sine of the Suns Altitude a = Co-sine of the Latitude, then take out the = Sine of the Latitude and make it a = in the Co-sine of the Suns Altitude, and lay the Thred to the N. D. and on the Degrees it gives the Suns Azimuth required from East or West, counting from the head, or from South, as the Degrees are figured.

Example, Latitude 51:30, Altitude 20, Declination 0, the Suns Azimuth from the South will be 62 Degrees 48 Minutes.

Or

Or you may work it by Tangents thus:

Take the Co-tangent of the Latitude, from the Tangents on the moving Leg, or loose Piece; and lay it on the Sines, from the Center downwards, and note the place (for that Latitude.) Then from the same Tangents take out the Tangent of the Suns Altitude, and setting one Point in the noted place, lay the Thred to the N.D. and on the Degrees it gives the Suns Azimuth required.

By Artificial Sines and Tangents thus:

As C. T. of the Latitude, to the Tangent of the Suns present Altitude; So is Sine of 90 to the Sine of the Suns Azimuth from East or West.

Or as C. T. Lat. to Sine 90, so is T. of Suns Alt. to S. of the Suns Azimuth.

2. *To find the Suns Azimuth in Summer in any Latitude and Declination.*

Having found the Vertical Altitude by the former Rule, find the Difference between it and the present Altitude, on a Line (or by the

the Table) of Natural Sines, and remember it; then take the — Sine thereof between your Compasses, and make it a = Sine in the Co-latitude, and lay the Thred to N. D. then take out the = Sine of the Latitude, make it a = in the Co-sine of the Suns Altitude, and lay the Thred to the N. D. and on the Degrees it gives the Suns Azimuth from South as figured, or from East or West counting from the Head.

Example, Latitude 51.30, Suns Altitude 25, Suns Declination 15 Degrees North, the Vertical Altitude is 19.22, then this taken from 25 on Sines, remains the Sine of 5 deg. 13 min. and the *Suns* Azimuth found thereby is 82.45 from South.

Note also, That in Southern Declinations or Winter, the same Rule holds, using the Sum of the Sines of the Suns Vertical Depression and present Altitude, till that Sum shall exceed the Complement of the Latitude, then use the Amplitude as followeth afterwards: Or else thus,

Take the Tangent of the Latitude from the moving Leg or loose Piece, and lay it on the Sines from the Center downward, and note the place for that Latitude; then make the — Sine

—Sine of the Suns Co-altitude taken from the leſſer Sines a = in the noted place or Tangent, lay the Thred to N. D. then take out the Sine of the Sum of the *Suns* Vertical Depreſſion and preſent Altitude, and find the N.D. from the Common Line and Thred, then the meaſure from thence to the Center, is Azimuth from Eaſt or Weſt, or from South counting from 90.

To work the ſame by Sines and Tangents on a *Gunter's* Rule in another *Example*, *viz.* Latitude 17.0, Suns Declination 10.0, the Suns preſent Altitude 60.

1. As the Sine of the Latitude 17, To S. of the Suns Declination 10; ſo is S. 90, to S. 36.26, the Vertical Altitude, which on a Line of Natural Sines taken from 60, the Sine of the Suns preſent Altitude, remains the Sine of 15.47 for a reſidue.

2. As C. S. of Lat. 73.0, to the S. of the reſidue 15.47, ſo is the S. of the Latitude 17.0, to a fourth Sine 4.46½.

3. As C. S. of Suns Alt. 30, to S. of the fourth 4.46½, ſo is S. 90, to S. 9.35 the Suns Azim. from the Eaſt or Weſt.

Or

Or thus by help of the Line of Tangents at one Operation.

As C. S. of Suns *Altitude* 30, to the *Tangent* of the *Latitude* 17.0, so is the S. of the Difference in Summer, or the Sum in Winter, of the Natural Sines of the Suns vertical and present *Altitude* (in this *Example*) 15.47, to the Sine of the Suns Azimuth from East or West, *viz.* 9.35.

But when the Suns Declination is more than the *Latitude*, and the same way, work thus by the Triangular Quadrant, *Example*, As before in the *Latitude* of 17 deg. North, the Suns Declination 23.30, the Suns *Altitude* 80, to find the Suns Azimuth, the whole Work is thus:

Take the — Sine of 17 the *Latitude*, make it a — in 23.30, lay the Thred to the N. D. and on the Degrees it gives 47.10, counting from the Head, or 42.50 as figured, being the Secant of the *Vertical Altitude*.

Then count this Secant on the Line of Tangents, on the moving Leg or loose Piece on the Common Line, and take the *Extent* from thence to the *Center* (and this is

the true *Secant* of the Suns *Vertical Altitude*, to the Radius of the moving Leg or loose Piece, according as you take it) and set one Point in the Sine of the Suns *Altitude* counted in the greater or lesser Sines, according as you took the Secant from the moving Leg or loose piece, and it shall reach beyond the Center, the Compass Point so stayed, take the — *Extent* from thence to the Center between your Compasses: and this is the *Extent* to be used instead of the residue as before, being the Sine of 22.16, plainly thus:

Count 42.50 from the *Center* at 60 on the loose Piece, being Tangents, to the Radius of the lesser Line of Sines beyond the Center, and take the *Extent* from the Common Line to the Center; lay the same *Extent* from 80 on the lesser Line of Sines, Laterally, and it reaches beyond the Center, then the *Extent* from that Point to the Center, measured from the Center on the small Line of Sines, gives 22.16, being the Secant of the Vertical *Altitude*, and the versed Sine of the Sums present *Altitude*, less by the Radius.

Then as before take this 22.16 from the larger Sines, make it a =, is the Co-sine of the *Latitude*, *viz.* 73, lay the Thred to N. D.

Then

Then take out the = Sine of the *Latitude* 17, make it a = in the Suns *Co-altitude* 10, lay the Thred to N. D. and on the Degrees it gives 41.50 the Suns Azimuth from the East or West, or 48.10 the Suns Azimuth from the South as figured.

To work this last *Example* by the *Gunter's* Rule.

As the S. of the *Latitude* 17, to the S. of the Suns Declination 23.30, So is the S. of 90, to the Secant of 42.50 (turning the Compasses from 90 backward (if it be not divided beyond 90) and counting from 90) the *Vertical Altitude.*

Then out of the Table of Natural Secants take the Secant for 42.50, *viz.* ———	1.36363.43
Also seek for the Natural Sine of 80 the Suns *Altitude*, *viz.* 98480.77. ———	
Whose Arithmetical Complement is ———	.01519.23
The Sum of the Two Numbers added together is ———	1.37882.66

Which sought in a Table of Natural Sines, neglecting the Radius, is the Natural Sine of 22 Degrees and 16 Minutes, to be used as a residue. Then

As the C. S. of the Suns *Altitude* 10, to the T. of the *Lat.* 17, so is that S. of 22.16 to the S. of 41.50, Azimuth from East to West.

To find the Suns Azimuth in Winter, or Southern Declinations, using the *Amplitude* First by the second Rule of this Section, find the Suns Amplitude, and note it.

Then make the — Sine of the Suns present *Altitude* a = Co-sine of the *Latitude*, and lay the Thred to the Neareſt Diſtance, and take out the = Sine of the *Latitude*, then add this *Extent* on Natural Sines to the Sine of the Suns Amplitude, and take the whole *Extent* between your Compaſſes for a Sum.

Then ſet one Point in the Co-ſine of the Suns *Altitude*, and lay the Thred to the N. D. and on the Degrees it gives the Suns Azimuth required from East or Weſt, counting from the Head or from South, as figured.

Ex-

Example, In *Latitude* 51.30, Suns *Altitude* 12 Degrees, Suns Declination South 10.0, to find the Suns Azimuth from South.

Make the —Sine of 10 a =Sine of 38.30, and lay the Thred to the N. D, and it gives 16 deg. 12 min. for the Suns Amplitude, which remember: Then

Make the —Sine of the *Suns Alt.* 12, a = Co-sine of *Lat.* 38.30, by laying the Thred to N. D. then take out the = Sine of the *Latitude* 51.30, then add this *Extent* to the Sine of 16.12 the *Amplitude* first found, by setting one Point of the Compasses in the Sine of 16.12, on the general Lines: and extending the other Point downward, it reaches to 32.48, for a Sum; then take the whole *Extent* from the *Center* to 32.48, and make it a = in the Sine of 78 the *Co-altitude*, and lay the Thred to N.D. and it cuts 56 deg. 20 min. the Suns Azimuth from South.

Another *Example* in another *Latitude*, *Latitude* 17 deg. Suns Declination South 10 deg. Suns present *Altitude* 36, the Suns *Amplitude* will be 10.28, and the Suns Azimuth from South 63.30, or 26.30 from East or West.

The whole Work by *Gunter's* Rule is thus:

1. As C. S. *Lat.* to S. 90, so is S. of Suns Declination, to S. of Suns Amplitude. Then

2. As C. S. *Lat.* to S. of Suns *Altitude*, so is S. *Latitude* to a fourth, which added on Natural Sines, to the *Sine* of the *Suns* Amplitude, gives a *Sum*.

3. As C. S. of the Suns present *Altitude* to the Sine of the Sum, so is S. 90 to S. of Suns Azimuth from East.

Thus you have two ways, one by the Natural Sines, and the other by the Artificial Sines and Tangents, as easily remembred, and as ready in any Operation as any extant, to find those two useful Propositions of Hour and Azimuth in any *Latitude*; and those on a portable Rule, giving the Suns *Altitude* to competent exactness, if well and workman-like handled.

Also having the *Altitude* at 6, Or the *Vertical Altitude*, noted with a spot of Ink for one day, it is found near as soon as by the particular way.

There

There is yet another way by Natural Verſed Sines, ſomewhat more eaſie and free from Excurſions, in brief worded thus:

The uſual way of placing the Natural Verſed Sines on a Sector or Quadrant, is to begin at the Center of the Quadrant or Sector with 0, 90 in the middle of the Radius or Leg, and 180 at the end.

Then count 0 at the beginning the Elevated Pole, 90 at the middle of the Equinoctial, and 180 at the end the depreſſed Pole.

Then from 90 or the Equinoctial, count the Suns Declination the ſame way as it is North or South, and it gives the Suns Diſtance from the Elevated Pole, being more or leſs than 90, according to the time of the Year: This being premiſed, then thus for the Hour,

1. Find the Sum of the *Co-latitude*, and the Suns Diſtance from the Pole by Addition, and the Difference between them by Subſtraction.

2. Count the Sum and Difference on the Line of Verſed Sines, and with Compaſſes take the — *Extent* between them.

3. Make this *Extent* a = Verſed Sine of 180, and lay the Thred to N. D. and note the place it lies on, or ſo keep it.

4. Take the — *Extent* on Verſed Sines from the Sum firſt found, and the Suns *Co-altitude* with Compaſſes.

5. And carry it = between the Common Line and the Thred till it ſtay at N. D. which ſhall be the Hour required from 6, counting from 90 or the Equinoctial: from Noon counting from the *Center*, or from Night counting from 180.

Example, *Latitude* North 20 Degrees, Suns Declination South 15 Deg. Suns preſent *Altitude* 15 Deg.

The

The Suns Distance from the Pole (that is Elevated Pole) is	105.0
The *Latitudes* Complement is	70.0
The Sum found by Addition is	175
The *Difference* found by *Substraction* is	35

As — *V. S.* of Sum and Difference, to = *V. S.* of 180: So is — *V. S.* of Sum and Suns *Co-altitude* to = *V. S.* of Hour 7.30: if the Sum be above 180, count the exceſs from 180 backwards.

To find the Suns Azimuth by the Natural Verſed Sines.

1. Of the *Co-latitude* and *Co-altitude* find the *Sum* by Addition, and the Difference between them by *Substraction*.

2. Count this *Sum* and *Difference* on the Verſed Sines, and with Compaſſes take the *Extent* between them Laterally.

3. Make this *Extent* a = Verſed Sine of 180, laying the Thred to N. D.

4. Take

4. Take the — *Extent* on Verſed Sines between the Sum or Difference firſt found, and the Suns Diſtance from the Elevated Pole.

5. The Compaſſes ſo ſet carry them = between the Common Line and the Threds till it ſtay at the N. D. which will be in the Suns Azimuth from Eaſt or Weſt, counting from 90.

Example, *Latitude* 20.0 North, the Suns Declination 15 South, and the Suns preſent *Altitude* 20 Degrees, what is his Azimuth?

The Suns *Co-altitude* —	70.0
The *Co-latitude* is —	70.0
The Sum is —	140
The Difference is —	00

Then the — *Extent* from 0 to 140 on Verſed Sines make a = *V. S.* of 180. Then the *Extent* from 140 to 105 the Suns Diſtance from the elevated Pole, carried = between the Common Line and the Threds ſhall ſtay at 25.20 the Suns Azimuth from the Eaſt or Weſt Points, or 64.40 from South.

By one of these three ways you may find the Hour and Azimuth in any place at any time, and prove one way by another.

CHAP. XII.

The Use of the Almanack.

THis Almanack hath nine or ten Ranks of Figures and Letters: Whose Names are expresst at the left end, *viz.* W. D. for Week Days, D. L. for Dominical or Sunday Letter, L. Y. for Leap Years, and Epact for the Epacts in those Leap Years, Months for the 12 Months in Numeral Figures, according to the old *Roman* Account, *viz. March* the First, and *February* the Twelfth Month: and lastly, 7 Ranks for 5 times 7 days called days; and the use is thus,

1. *To find on what Week-day the First of* March *or the First Month falls on.*

If it be a Leap Year, and Expresst in the Almanack, then the Week day Letter right over

over it, answers the Question, as in the Year 1680 the Letter M. for Munday right over it, shews that the First of *March* was Munday in the Year 1680.

But if the Year propounded be not Leap Year, then seek for the last Leap Year next before the Year propounded, and count successively as the days proceed, and you have the day required. *Example*, In 1683 to find on what Week-day the First of *March* will be. The Leap Year next before 1683, is the Year 1680, and then the Almanack shews the First of *March* was Monday, in 1681 it was Tuesday, in 1682 Wednesday, in 1683 Thursday, the Answer to the Question, and the next Leap Year, *viz.* 1684, which is expresst in the Almanack, it will be Saturday as the Letter Sa. over 1684 sheweth.

2. *Having the Day of the Week the First of* March *is on, to find the Week day of any Day, any Month that Year, and the contrary.*

Seek the Month among the Rank of Months, calling *March* the first, and the rest in order, according to the old Account, then all the days right under are the same days

days of the Week that the First of *March* was; and so counting orderly from the next neareſt day, you have your deſire. *Example*, On the 25*th* of *Auguſt* 1683, What Week-day is it?

By the Firſt Rule I find the Firſt of *March* 1683 to be Thurſday, then *Auguſt* being the ſixth Month from *March*, ſeek 6 in the Rank of Months, then all the days right under, *viz.* the 2, 9, 16, 23, and 30th are all Thurſdays, then the 23d. day being next or neareſt to 25, if the 23d. be Thurſday, the 25th muſt needs be Saturday, and ſo for any other. On the contrary, knowing the day of the Week to find the day of the Month. *Example*, In *October* 1683 on a Wedneſday near the beginning, what day of the Month is it, ſeek 8 for *October*, the 8*th* Month from *March*, and all the days right under being Thurſdays, and the day named Wedneſday and near the beginning of the Month, muſt needs be the *third* or the *tenth* required.

3. *To find the Epact any Year for* 28 *Years to come.*

In every Leap Year you have it expreſt in the Almanack right under it, for every Year be-

between, add 11 to what it was in the Leap Year, and the Sum if under 30, or the remainder 30 ſubſtracted, is the Epact for that Year.

Example, In 1685, What is the Epact?

Look in the Line of Leap Years for the laſt Leap Year before the preſent Year propounded, which is 1684, the Number 23 right under it was Epact then, then the Year propounded being 1685 one Year after it, add 11 to 23, it makes 34, from which taking 30, remains 4 for the Epact 1685. If it be two Years after the Leap Year add 22, if 3 Years after Leap Year add 33, and the remainder 30 being ſubſtracted, is the Epact for the preſent Year propounded.

4. *Having the Epact and Day of the Month, to find the Moons Age.*

Add to the Epact the Month, and day of the Month, calling *March* 1, *April* 2, *May* 3, *June* 4, &c. the Sum if under 30 is the Moons Age to a day, but if the Sum be above 30, and the Month have 31 days, then ſubſtract 30, and the remainder is the Moons Age; but if the Month have but 30 days, then ſubſtract but 29, and the remainder is the Moons Age to a day.

Example, On the 30th of *October* 1683, What is the Moons Age?

The Epact as found by the last Rule for the Year 1683, is 12, to which adding 8 for the Month and 30 for the day of the Month, makes 50, from which taking 30, because *October* hath 31 days, remains 20 for the Moons Age on the 30*th* day of *October* 1683.

5. *Having the Moons Age, to find its coming to South.*

Multiply the Moons Age by 4, and divide the product by 5, the quote is the time of Southing. *Example*, The Moons Age being 9 days old, 9 times 4 is 36, which divided by 5, hath $7\frac{1}{5}$, or 7 a Clock and 10 Minutes, 3 Hours after at New and Full Moon it is High Water, but at the Quarters between, it is found to be sooner by an Hour, *viz.* at 2 Hours after the Moons coming to South, and gradually between.

But Note, This work is better done by the Line of 24 Hours, and the Line of 29 or 30 the Moons Age. Thus seek the Moons Age in the Line of her Age, and just against

against is the time of coming to South in the Line of 24 Hours, and 3 Hours after at New and Full Moon is High Water at *London*, and 2 Hours after at 7 days and 22 days old.

6. *To find the Hour of the Night by the Shadow caused by the Moon on a Sun Dial, at any time of her Age, by the two Lines of* 30 *and* 24.

The Extent of a pair of Compasses from 12 in the 24 Hours, to the Moons Age in the Line to 30 or $29\frac{2}{3}$, being laid the same way from the Hour shewed by the Moon on the *Sun Dial*, and counted on the 24 Hours, shall stay at the Hour of the Night required.

Example. The Moon being 12 and $\frac{1}{2}$ days old, and shewing 9 a Clock, what is the true Hour? The Extent from 12 Hours to 12 days and $\frac{1}{2}$ in the Line of the Moons Age, shall reach the same way from 9 to 7 and 3 Minutes, the near true Hour required.

By the Fifth Rule just before, you may find the Moons Southing by the Pen, then the Complement thereof to 12, substracted in the increase of the Moon: or added in the decrease

decreaſe to what the Moon ſheweth on the Sun Dial is the near time of the Night.

Example. At 10 days old the Moon cometh to South at 8 at Night, whoſe Complement to 12 is 4 Hours. Then ſuppoſe the Moon ſhew 11 a Clock 4 Hours leſs, *viz.* 7 is the near true Hour. But if the Moon be 20 days old, and ſhew 9, it is then near 1 a Clock, adding 4 Hours to 9.

CHAP. XII.

The Uſe of the Quadrat and Shadows.

THeſe Lines are uſually ſet next the Degrees, and numbred from the Head Leg toward, and alſo upon the Looſe Piece.

The Quadrat begins at 90 at the Head Leg with 10, 20, 30, *&c.* to 100, againſt 45 then the Line of Shadows with 200, 300, 400, *&c.* to a 1000 at 5,42½ on the

loose Piece; Also the Line of Shadows, as to the 10 parts, is continued among the Divisions of the Quadrat to 10 at 84.18.

Then the Quadrat and Shadows together are Natural Tangents of the Arks cut by them on the Degrees.

Use 1. *To find any Accessible Altitude by the Shadows at one station.*

If you hold up the Rule, looking toward the Object by the Head Leg, going to or fro, till the Thred cuts 100 on Quadrat or 45 Deg. then the perpendicular Altitude of the Object above the level of the Eye, is equal to the Distance between your standing and the Foot of the Object.

If it falls on 200, the distance is double to the height; but if it falls on 2 among the Quadrat, the height is equal to twice the Distance.

But for a general Rule, counting the Quadrat as part of the Shadows, say by the Line of Numbers always, As the parts cut by the Thred on the Quadrat or Shadows, is to 1, so is the measured Distance to the height.

En-

Example, As 46.31 on Quadrat to 1, so is 37 Yards and ½ measured, to 80½ the height.

2. *A second way.*

Measure 10 Yards or 100 Foot, or 10 of any Measures from the Foot of any Object whose height you would know, and there observe as before, and note the parts cut on Degrees, then count the same Degrees backward from 90, and the Thred there laid, on the Quadrat or Shadows, gives the Altitude in the same Feet or Yards. *Example.* In the last at 100 Foot from the Object I find 38 deg. 50 min. the Thred laid to the same from 90, cuts 80 Foot and ½ the Altitude required.

3. *A third way by the Shadow of any Object on the level ground.*

Measure the length of the Shadow, and get the Suns Altitude the same time, and the Thred in the Line of Shadows cuts the Altitude: at 45 the Shadow and Altitude is equal, at 200 the Shadow is twice as long, at 22 among the Quadrats half as long.

But for a general Rule, work thus, at any Altitude or Measure of the Shadow, any time of the day.

The Extent on Numbers from the parts cut on Quadrat or Shadows to 1, shall reach the same way from the measured Shadow to the Altitude.

Example, If the measured Shadow be 136 Foot, and the parts cut by the Thred on Shadows 1.695, then as 1.695 to 1, so is 136 to 80.5.

Or again, in another *Example*, the measured Shadow being 37 Yards $\frac{1}{2}$, and the Thred cutting 46.63 on the Quadrat, say by Numbers, As 46.63 the parts cut, to 1: So is 37.50 the measured Shadow, to 80 Yards and $\frac{1}{2}$ the Altitude required.

4. *For inaccessible Altitudes by Quadrats and Shadows.*

First at the neareſt, convenient, or appointed place, look up to the Object whose height is required, and note carefully the parts cut by the Thred on the Quadrat or Shadows.

Then

Then go backwards any competent measured Distance in a right Line between the Object and first Station, and observe there again, and note the parts cut by the Thred.

Then substract the part cut by the Thred at one Station from the parts cut at the other Station, and note the Remainder for a Divisor, to divide the measured Distance between the Stations by, and the Quotient is the Answer.

Example, Suppose at 37 Yards and ½ or any unknown Distance, I observe the top of a Tower or Tree, and the Thred cuts 65 on Degrees or 46.63 on the Quadrat, from thence I go back 99 Yards, and observe at that second Station, and the Thred cuts on the Shadows 169.76, then Substraction being made, *viz.* 46.63 from 169.76 and the remainder is 123.13. Then by Numbers say, as 123.13 to 1, So is 99 Yards the measured Distance, to 80 Yards and ½ the Altitude.

For if by Arithmetick you add Cyphers to 99 the measured Distance, and divide it by 123.13, the Quotient will be 80 Yards and near a half.

This way is general at all times and stations, both for Heighths and Breadths.

5. *Another way by the Line of Shadows.*

Observe the Altitude at any convenient Distance, and note the parts cut on the Line of Shadows or the Quadrat, then move backward in a right Line till the Thred cut as much more as at the first Station, then the Distance between the two Stations is equal to the heighth.

Example, Suppose at the first Station it fell on 1 of the Shadows, there leave a mark and go back till it falls upon 2, then the Distance between is equal to the Altitude above the level of the Eye. Also, If at the first Station it shall fall on 50 in the Quadrat, which is half of 1, and in the second Station at 1.50 in the Line of Shadows, the Measure between the Stations is equal to the heighth.

6. *To find an Altitude at Two Stations by the Degrees, and general Sines and Lines.*

Find the Altitude at one Station on the Degrees, and count it from the Head Leg, and leave a Mark at that *Station*, then go backwards any competent distance, and observe again by the Degrees, counting from the Head Leg.

Then substract the Degrees found at one *Station* from the Degrees found at the other *Station*, measuring the Distance between the Two *Stations*. *Example*, Suppose at the first *Station* I find the Thred cut 30 Degrees from the Head, at the second *Station* the Thred cuts 60 Degrees from the Head, then 30 taken from 60, there remains 30 Degrees for a Difference.

Then suppose the measure between the two *Stations* be 72 Foot 20 parts, here observe that the Angle at one *Station* being but half the Angle at the other *Station*, the measure between the *Stations* is equal to the Hypothenusa, or Scaling Ladder at the first *Station*.

Then the Altitude is found at one Operation thus:

As *S.* 90 to the measured Distance on Numbers 72.20, so is the Co-sine of the Angle at the first *Station* 60 to the Altitude 62.50.

By the Line of *Sines* and the *Thred*, and equal Parts or Lines, work thus:

Take the Extent laterally from the Center where the Thred is fastened to 72.20 on the Line of Lines, set one Point in 90 of the *Sines*, and with the other lay the Thred to the Neareſt Diſtance, and ſo keep it.

Then the Parallel Extent or Neareſt Diſtance from the *Sine* of 60 to the Thred laid laterally from the Center on the Line of Lines, ſhall reach to 62.50 the Altitude required.

But the general way is thus at two Operations:

As the Lateral meaſured Diſtance 72.20, to the Parallel *Sine* of the oppoſite Angle 30, ſo is the = *Sine* of the Co-altitude at the ſe-

cond

cond *Station* 30 to 72.20 the Hypothenusa at the first *Station*.

2. As — 72.20, to = *S.* 90 the opposite Angle, so is = *Sine* of 60 the Complement of the Angle at the first *Station*, to — 62.50 the opposite side, being the Altitude required. *Note*, This Rule serves to find any Breadth or Distance as well as Heighth.

7. *To find a Breadth or Distance at any two Stations by protraction.*

Let C D be two Marks at a Competent Distance, whose Breadth between and the Distance to them is required.

As you stand set up a Mark as at A, and any way you shall find convenient set up another as at B, 94 Foot from it, or more or less.

Then set up your Instrument horizontally on a three Leg Staff or the like, and direct the fiducial Line of Sines and Lines by the sights to the Mark at A, the Instrument standing directly over B; then move the Index from A to C, noting the Degrees cut, which suppose to be 39; then remove the Index to D, and note what it cuts, which suppose to be 103.30. Then

Then bring the Instrument to the Mark at A, setting the Center right over the mark A, and turn the Sines and Lines, to look right to the mark at B, and there fix the Instrument: Then move the Index to D, and note the degrees cut, which suppose to be 44.20; also remove it to C, and note the degree cut, which let be 111.40.

Then by these Observations you may draw the Figure as annexed, and find all the sides and angles required in this manner:

Draw the line A B, and from any convenient *Scale*, as the *Line of Lines* or *Hours*, take off 94 parts, and lay it from A to B; then on the points A and B, as on two Centers, draw two Arches with the Sine of 30 degrees between your Compasses; and lay off the angles observed at both Stations, *viz.* 39 from A to C, and 103.30 from A to D, and draw those lines extended: Then on the point A lay off 44.20 from B to D, and 111.40 from B to C; then note where those lines produced intersect one another, is the points C and D; then the Figure being drawn, you may by your *Scale of Equal parts* measure any side or distance, and by the *Chords* measure any angle.

Many

Many other ways may you find in the Book of *The Triangular Quadrant* at large set forth.

CHAP. XIII.

The Use of the Line of Sines *from the Center upwards and downwards, also of the* Line of Tangents *on the Moving Leg and Loose Piece in* Protraction.

1. *The Sine of any Arch or Angle given, to find the Radius or any other Sine to the same Radius.*

1. TAke the Sine given between your Compasses, make it a = in the Sine given, and lay the Thred to the N. D. and so keep it, then the = Sine of 90 shall be Radius, and the = extent from any other Sine to the Thred, shall be the required Sine in the same Radius, and in proportion to the first Sine given.

2. *The*

2. *The Radius being given, to find any Tangent or Secant to the same Radius by the Sines only.*

Take the Radius given between your Compasses, set one point in the Sine Complement of the Tangent required, lay the Thred to the N. D. and so keep it; then the nearest distance from the Sine of the Tangent required, shall be the Tangent, and the N. D. from the Sine of 90 to the Thred, shall be the Secant required.

3. *Any Tangent or Secant being given, to find Radius, and then any other Tangent or Secant to the same Radius required.*

If the Tangent be given, make it a = in the Sine thereof, and lay the Thred to the N. D. then the = Cosine thereof is Radius.

If the Secant be given, make it a = in Sine 90, and lay the Thred to the N. D. then the = Cosine of the Secant given shall be Radius required: then having the Radius, the last Rule will help you to the Tangent or Secant to the same Radius.

4. *To lay down any Chord to any Radius equal to, or less than the Sine of 30 on the general Scale of Sines.*

Take the given Radius, make it a = in the Sine of 30, and lay the Thred to the N. D. and so keep it (noting what degree the Thred cuts) then the N. D. from the Sine of half the Chord required, shall be the Chord required to that Radius.

5. *To lay down any Chord or Angle by any Line of Sines, as the particular Scale of Sines, the greater general Scale of Sines from the Center downward, or the lesser Sines from the Center upward, or the Azimuth Line, being all Natural Sines.*

Take the — Extent from the beginning of the Line of Sines, to the Sine of 30 degrees, being counted 60 of Chords; and with that Extent draw the Arch of a Circle from any given Point and Line: then the — Sine of half the Chord required, shall be the Chord of that Arch or Angle required.

Or if you like not to draw an Arch, take the whole Line of Sines from the beginning to 90, and lay it from the Point from whence you would raise the Angle on any Line to another Point.

Then take the — Sine of the Angle required, and setting one Point of the Compasses in the Point last made in the Line from whence you would raise the Angle, and with the other draw a touch of an Arch, then a Rule laid from the intended Center to the convexity of that Arch shall be the Angle required.

6. *To lay down any Sine, Tangent, or Secant, to Two fixed Radiusses, viz. The greater or lesser Scale of Sines on the Head Leg.*

The Lateral Sine counted on the Sines from the Center upward for the lesser, or downward for the greater, shall be the Sine.

The Lateral Extent from the Center at 60 on the loose Piece, is the Tangent to the same less Radius, and the — Extent from the Center at 60.0 on the moving Leg

ſhall be a Tangent to the greater Radius.

Alſo the meaſure from any Tangent on the looſe Piece (in the Line the Center Pin ſtandeth in) to the Center, ſhall be the Secant to the ſame leſs Radius.

And the meaſure from any Tangent counted on the moving Leg to the Center, ſhall be the Secant of that Angle or Arch to the greater Radius.

Alſo *Note*, If you have occaſion of a Secant or Tangent to more than 45 of the greater Radius, take the leſſer Radius, and turn the Compaſſes three times, and that ſhall ſupply it, becauſe the leſſer Radius is juſt one third part of the greater, and ſo are all other Arches in Proportion.

7. *To find any Natural Sine, Tangent or Secant, to four places, by the Logarithmal Lines of Numbers, Sines and Tangents.*

For any Sine under 90, or Tangent under 45 (which is Radius) take the Extent from Sine 90, or Tangent 45, to the Sine or Tangent required; that Extent laid the ſame way from 10 on the Line of Numbers, and

and reading it as a Scale of equal parts, ſhall be the Natural Sine or Tangent required. *Example*, The Extent from 90 on the (Artificial or Logarithmal) Sines to 30, ſhall reach from 10 on the Line of Numbers to 500, which is the Natural Sine of 30 (or Right againſt 30 in the Sines is 5 in the Line of Numbers.

Alſo right againſt the Tangent of 30 is 5773 in the Line of Numbers, or the Extent from 45 to 30 on Tangents, reaches from 10 on Numbers to 5773 the Natural Tangent of 30 the ſame way.

But to find the Natural Tangents above 45, the Extent from 45 to the Tangents above 45, reading it backwards as figured, being laid increaſing from 1 in the Line of Numbers, gives the Natural Tangents required. Thus the Extent from 45 to 70 at 20 his Complement, laid from 10 on Numbers, gives 2.747 the Natural Tangent required.

Alſo the Meaſure from Sine 90, to the Cofecant required, meaſured increaſing from 1 on Numbers, ſhall be the Natur. Sec. required.

Thus the Extent from Sine 90, to Sine 20, the *Complement* of 70, being laid from 1, gives 2.924 the Natural Secant of 70 *deg.* required.

F I N I S.

THE USES Of a Convenient Gunners Rule for most of their Occasions; For all sorts of Great Guns.

By *JOHN BROWN.*

LONDON, Printed 1684.

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THE USES of a Convenient GUNNERS RULE.

1. *The Use of a Line shewing the weight of the Shot, having the Diameter of the Bore, or having the weight of the Shot, to find what the Guns Diameter of Bore must be, allowance being made for the wind or vent.*

COunt the Diameter of the Bore on the Line of Inches, then count backwards toward 1 a 20th part of that Diameter, and just against it on the Line called the Weight of Iron Shot, is the Diameter of the Shot required.

Example, I have a Gun whose Diameter at the Chamber or place where the Shot and Powder lies in the Gun, is 6 Inches: What is the Weight and Diameter of a convenient fit Shot?

Counr backward toward 1 a 20th part of 6 Inches, which is 3 tenths of 1 Inch, *viz.* at 5 Inches 7 tenths, and the Line of Iron Shot shews 26*l.* the weight, and the Shots Diameter is 5 Inches 7 tenths of an Inch.

On the contrary, having the weight of the Shot, seek it on the Line called Weight of Iron Shot, and just against it on the Inches is his Diameter, and one 20th part of the Diameter forward toward 8 Inches, is the Diameter of a Gun Bore to fit that Shot.

2. *To find the Experimental Weight of Powder (Tower proof) that is found convenient for service to use in Guns of several Fortifications or thickness (and by consequence strength) of Metal.*

To find the strength of Guns, the brief Rule is thus, Find the Diameter of the Chamber or Bore of the Gun where the Shot lies, then true bored and true fortified Guns of Iron ought to be 11 of those Diameters about the Gun at the Touch-hole, 9 at the Trunnions, and 7 at the Neck.

Bra

Braſs Guns bearing the ſame weight of Powder, are as ſtrong at 9 Diameters of the Bore (at the Chamber) about the Gun at the Touch-hole, 7 at the Trunnions, and 5 at the Neck, a little behind the mouth or moſſel ring, where the diſpart is ſet. This is the Rule and Meaſure of true boared and and true fortified Guns; and for thoſe more or leſs fortified by the Lines on the Scale marked and numbred thus;

Weight of Powder for Service, ruled by the number of Diameters of the Bore about the Gun at the Touch-hole, *viz.* For true fortified Guns, and for two ſorts leſs fortified, and for two ſorts of Guns better fortified, both for Iron and Braſs,

	Braſs		*Iron*
More fortified	11 } 12 }	Diameters	{ 13 { 10
True fortified Guns	9	Diameters	11
Leſs fortified	8 } 7 }	Diameters	{ 10 { 9

Thus having explained the meaning of the Lines, the uſe is thus:

Having found the ſtrength of the Gun, by comparing the Circumference of the Gun at the Touch-hole by the Diameter of the Bore as aboveſaid. Then ſeek the Guns Diameter on the Line of Inches, and juſt againſt it on that Line which comes neereſt the Fortification of your Gun found, is the weight of Powder fit for ſervice for ſuch a Gun.

Example, Suppoſe a Braſs Gun be found to have 9 Diameters of the Bore about the Gun at the Touch-hole: Or an Iron Gun of 11 Diameters at the ſame place, ſuch a Gun is counted true fortified.

Then the Diameter of the Bore being 6 Inches, ſeek 6 on the Line of Inches; then juſt againſt 6 Inches, on that middle Line marked 9 for Braſs, or 11 for Iron, is 10 pound $\frac{1}{4}$ the weight of Powder for Service for ſuch a fortified Gun, and half of 10 and $\frac{1}{4}$ added to $\frac{1}{4}$ makes 15 pound 6 ounces, the proof Powder for ſuch a Gun.

Again, Suppoſe I find the Iron Gun have but 9 Diameters about at the Touch-hole, and be 6 Inches Diameter in Bore, then juſt 6 Inches counted on the Line of Inches,

Inches, on that Line of 9 for Iron, or 7 for Brass, is 6 pound 6 ounces, the weight of Powder sufficient for such an Iron or Brass Gun for Service, and 3 pound 3 ounces more, in all 9 pound and 9 ounces for proof, and the like for any other Gun.

3. *The Use of the Line called Weight of Powder to fill 1 Inch.*

Having by the former Rule found the quantity of Powder to be used at one Shot, seek the Balls Diameter on the Line of Inches, and just against it on this Line is the pounds and 100 parts of a pound, that fills one Inch of a Carteridg of that Diameter, and by consequence you have the length of the Carteridge to hold the Powder due for such a Gun.

Suppose the Bullets Diameter be 6 Inches, and the answerable weight of Powder 9 pound, how long must the Carteridg be to hold it? Just against 6 Inches on the Line of Inches, on this Line is 0,875 for 0 pound 875 parts, the quantity of Powder that fills 1 Inch.

Then if you divide 9 pound the weight of Powder, by adding ciphers to 9, by 0.875 (the Numbers found on the Line, called weight of Powder to fill 1 Inch) the quotient shall be 10 Inches 3 tenths, the clear room in the Carteridg, beside room to tie it fast.

By the Line of Numbers work thus, the Extent from 0.875 to 1, shall reach the same way from 9 to 10 Inches 3 tenths the clear length required, beside room to sew or tie together.

4. The use of the Line called Pounds of Powder, to fill one Diameter of any Gun or Cillendar.

Some Gunners have observed that 2, 3, or 4 Diameters of the Bore is sufficient length for a Carteridg; but note that the greater the Diameter of the Bore is, the fewer Diameters in length will serve. *Example.* For a Demi-cannon, the Diameter of whose Shot is 6 Inches, and the weight of Powder for Service about 15 pound, in how many Diameters length will this Powder lie? Seek

for 6 on the Line of Inches, being the Shots Diameter, and just against it is 5 *l.* 46 parts the quantity of Powder lying in one Diamimeter of such a Cillender, then one Diameter holding 5 *l.* 46 parts, 3 Diameters will hold 16 *l.* and $\frac{1}{3}$; Therefore 3 Diameters of the Bore is length enough for the Carteridge. Again for a lesser Shot of 3 Inches Diameter, just against 3 Inches is 10 Ounces and $\frac{1}{2}$ the Powder in one Diameter, now a due charge for a Minion well fortified, that carries a Shot of 3 Inches Diameter, is 3 Pound of Powder, then one Diameter holding but 10 Onnces $\frac{1}{32}$, 5 Diameters holds 52 Ounces, a little more then 48 the Ounces in 3 Pound.

Again, A Cannon Royal, whose Shot is 63 Pound and 7 Inches 7 tenths Diameter, just against 7. 7 Inches on this Line is 11 Pound 25, the quantity of Powder in one Diameter; therefore little more then 2 Diameters long *viz.* 24 Inches, will serve to make a Carteridge for this Gun of 8 Inches Diameter in the Bore.

Note also, To fill a Sphere or Granado-shell of the same Diameter, two third parts of that which fills a Cillender will serve a Sphere,

so

ſo that if the Cillender by the rule of 7 Inches 14 parts hold 9 Pound, a Shell or Sphere of the ſame Diameter holds but 6 *l.* two thirds of 9.

3. To find the weight of Granado Shells by the Line, ſhewing the weight of Iron Shot at any Diameter.

With Calliper Compaſſes find the Diameter of the outſide of the Granado Shell, and by putting the Rule into the hole for the fuſe, find the greateſt Diameter on the inſide of the Shell, then by counting thoſe two Diameters on Inches, right againſt it on the Line called the Weight of Iron Shot, is the weight of an Iron Bullet anſwerable to thoſe two Diameters, then the leaſt weight taken from the greateſt, remains the weight of the Granado Shell required to be found.

Example.

If the outſide of the Shell be 12 Inches Diameter, the anſwerable weight againſt 12 Inches, on the Line for the weight of Iron Shot

Shot is 240 *l.* Then if the inside Diameter be 10 Inches and $\frac{1}{2}$, the answerable weight of such a Shot is 152 *l.* the 152 taken from 240, remains 88 *l.* the weight of the Granado Shell required.

6. *In like manner you have two other Lines to shew the weight of Leaden Shot, and Stone Shot, at any Diamter.*

For count the Balls Diameter on the Line of Inches, and just against it in the Line for Leaden Shot is the weight thereof; and just against the Diameter found on Inches, is the weight of the Stone Shot.

Example.

Let the given Diameter be 5 Inches and 7 tenths, the Iron Ball is 19 *l.* 3 quarters, the Leaden Ball is 29 *l.* $\frac{1}{2}$, the Stone Ball is 8 *l.* $\frac{1}{2}$.

7. *To*

7. To find the solid capacity of a Sphere in Cube Inches.

Count the Spheres Diameter in the Line of Inches, and right against it in the Line called the Spheres Capacity in Cube Inches, is the Answer required.

Example.

Suppose the inside Diameter of a Granado Shell or the like, be 10 Inches, seek 10 Inches on the Line of Inches, and just against it on this Line is 528 Cube Inches, the solid content of such a Sphere in Cube Inches. Then if a Cube Inch hold near half an Ounce of Powder, such a Sphere will hold 528 half Ounces or 16 *l.* as a Line near to this, which sheweth what Pounds of Powder a Sphere holds at any Diameter to 12 Inches Diameter, doth more plainly and readily shew at any Diameter.

8. T

3. *On one side of the Rule is the Ordinary Pieces Names: as,*

F. N. for Falconet, F for Falcon, 3 for a Dutch Piece whose Shot weigheth 3 Pound called a 3 Pounder, M. for a Minion, S. for a Saker, 6 for a 6 Pounder, D. C. for a Demy Culvering, 12 for a 12 Pounder, W. C. for a Whole Culvering, 24 for a 24 Pounder, D. C. for a Demy Cannon, B. C. for a Bastard Cannon, W. C. for a Whole Cannon, or C. R. for a Cannon Royal.

Note every stroke by those Names, counting from the end where the Inches begin, is the height of the Bore of those several Pieces.

And in another Margent is set the weight of those Pieces.

Then in another Margent is set the weight of Powder fit for those Pieces to use in service, and one half more serves for the proof Powder.

Then

Then in another Margent is ſet the weight of the Iron Shot for thoſe ſeveral Pieces.

In another Margent is ſet the length of the Ladle to charge them.

In another Margent the breadth of the Ladle to hold Powder to Charge them.

The heights of the Pieces, are ſometime cut on a broad Piece with diſcents like ſteps for the more ready Application into the Mouſel of thoſe ſeveral Guns; and then it is called a Height Board for the Gunners uſe.

Thus much for the Gunners uſe and Height-Board.

A General Table for Gunners.

Names of Pieces.	Leng. Piece.	Dia. Bore	Weig. Piece.	Weig. Shot.	Dia. Shot.	Weight Pound.
True fortif.	F.	I. 100	L. E.	P. O.	I. 100	P. O.
Can. Royal	12 0	8 00	8000	63 4	7 67	26 0
Cannon	12 0	7 00	6800	42 6	7 01	18 10
Demy Can.	10 5	6 50	5800	34 0	6 23	15 4
L.D. Can.	11 5	6 25	5400	30 3	6 00	13 6
1 Culver.	11 0	5 50	4800	20 8	5 25	9 3
2 Culver.	12 0	5 25	4500	17 12	5 00	7 13
3 Culver.	11 0	5 00	4000	15 4	4 76	7 4
1 D. Culv.	11 0	4 75	3000	13 3	4 52	6 8
2 D. Culv.	10 0	4 50	2700	11 0	4 27	5 10
3 D. Culv.	9 5	4 25	2000	9 2	4 02	5 1 3
1 Saker	9 5	4 00	1800	8 0	3 84	4 8
2 Saker	9 0	3 75	1500	6 4	3 53	3 10
3 Saker	8 0	3 50	1400	5 0	3 28	3 0
1 Minion	8 0	3 25	1000	4 2	3 10	2 6
2 Minion	7 0	3 00	850	3 5	2 85	2 0
Falcon	7 0	2 75	750	2 10	2 62	1 8
Falconet	6 0	2 25	500	1 10	2 10	1 0
Rabonet	5 0	1 50	300	0 6	1 40	0 6
Base	4 0	1 25	200	0 4	1 18	0 4
24 Pound.	11 0	5 79	5000	24 0	5 56	10 8
12 Pound.	10 0	4 61	3000	12 0	4 40	6 0
6 Pound.	9 0	3 70	1500	6 0	3 49	3 8
3 Pound.	7 0	2 94	750	3 0	2 77	1 10

A General Table for Gunners.

Names of Peeces:	Leng. Ladle	Brea. Ladl.	Leng. Cart.	Brea. Cart.	Proof Pow.
Trne fortifi.	*I.* 10	*I.* 10	*I.* 10	*I.* 10	*P. O.*
Can. Royal	24 0	15 0	16 4	24 1	40 0
Cannon	23 5	12 5	17 1	21 1	28 0
Demy Can.	23 0	11 5	16 2	19 6	22 10
L. D. Can.	20 0	11 8	15 4	18 9	20 4
1 Culver.	16 5	10 0	13 5	16 5	14 0
2 Culver.	15 0	9 0	12 8	15 7	12 0
3 Culver.	14 5	8 7	12 9	15 0	11 6
1 D. Culv.	14 0	8 6	13 5	14 2	11 0
2 D. Culv.	12 6	8 5	12 5	13 4	10 0
3 D. Culv	12 0	8 0	13 0	12 6	9 0
1 Saker	11 0	7 2	12 2	11 1	8 0
2 Saker	10 6	6 7	11 7	10 1	6 4
3 Saker	9 8	6 5	11 2	10 3	5 0
1 Minion	9 0	5 6	9 9	9 7	4 2
2 Minion	8 4	5 0	10 0	9 9	3 5
Falcon	8 0	4 6	8 7	8 2	2 10
Falconet	7 0	4 0	8 7	6 6	1 10
Rabonet	6 0	2 6	7 2	4 7	0 12
Base	4 5	2 0	6 3	3 7	0 8
24 Pound.	18 0	11 0	14 0	17 4	15 12
12 Pound.	14 0	9 0	12 7	18 8	9 12
6 Pound.	10 6	6 5	11 7	11 0	5 0
3 Pound.	9 0	5 5	8 6	8 7	2 8

The use of this Table is thus, In the first Collum you have the Names of the Pieces, in the second the length of the Pieces in feet and decimals, or half feet, in the third Collum the height of the Bore in Inches and 100 parts, in the fourth the usual weight of the Pieces in Pounds, in the fifth the weight of the Shot of Iron in Pounds and Ounces, in the sixth the Diameter of the Shot, in the seventh the weight of the Powder for service in Pounds and Ounces.

In the second part you have the length and breadth of the Ladle according to Mr. *Nath. Nye*, the length and bredth of a Carteridge, that is the length, and circumference of the Roller on which it is made. In the last Collum is the weight of the proof Powder for true fortified and true bored Guns; for others use proportion.

The Use of the Line of Numbers on Gunners Rules.

To find the Weight of Iron Shot.

1. It is experimented that an Iron Shot of 8 Inches Diameter doth weigh 72 *l.* Then to

find the weight of any other Iron Shot, as suppose a Shot of 6 Inches Diameter, the extent from 8 to 6 on Numbers, being repeated three times the same way from 72 the weight of the Shot of 8 Inches Diameter, give 30 *l.* 6 Ounces the weight of an Iron Shot of 6 Inches Diameter.

On the contrary, the weight being given to find the Diameter.

Divide the extent on Numbers between 72 the fixed weight for 8 Inches Diameter, and 30 *l.*-375 the weight given to find a Diameter, into 3 equal parts, that extent laid the same way from 8 reaches to 6 the Diameter required.

Note, If a Shot of Iron 8 Inches Diameter, be 72 *l.* a Lead Shot of the same Diameter is 103 *l.* ½, a Brass Shot of the same Diameter is 80 *l.* 12 Ounces; and a hard Stone Shot of 8 Inches Diameter weigheth 26 *l.*

Mr. *Nye* saith that five pound of Lead and one pound of Pebble Stones mixed together, makes a Stone Shot equal in diameter and weight to an Iron Shot, to use instead of Iron of 8 *l.* weight.

And so in proportion, as suppose I would make a Lead and Stone Shot of 4 Inches Diameter, such an Iron Shot weigheth 9 pound one sixth part of 9 *l.* is 1 *l.* 8 Ounces, and 5 $\frac{5}{6}$ parts is 7 $\frac{1}{2}$, which together makes 9 *l.* and the Mould is to be 4 Inches Diameter.

2. Having the weight of one Gun, to find the near weight of another of the same shape and of the same mettal, or another mettal.

A Demy Culvering of Brass of 13 Inches Diameter at the touch hole doth weigh usually 2700 *l.* weight, what shall a Brass Saker weigh of 10 Inches Diameter at the touch hole.

The extent on a line of Numbers from 13 Inches to 10 Inches, laid three times the same way from 2700 falls upon 1236.

On the contrary, the weight given to find the Diameter.

One third part of the extent between weight and weight counted on a line of

Numbers, ſhall reach from one Diameter to another.

But if the Saker be of Iron, then to find its weight, ſay as $80\frac{1}{4}$ the proportion for Braſs, is to 72 the proportion for Iron, ſo is 1236 the Braſs Sakers weight, to 1102 *l.* the Iron Sakers weight.

3. From one good experience of the weight of Powder uſed to a Gun of true fortification, to find a fit weight of Powder for another Gun of like fortification, or a ſtronger or a weaker fortification.

It is experimented that a whole Culvering whoſe Diameter of Bore is 5 Inches and a half, and true fortified ſhooteth a Shot of Iron of 20 *l.* and $\frac{1}{2}$ with 9 *l.* three Ounces of Powder, how much Powder will ſerve a Gun whoſe Bore is 4 Inches 61 parts.

The extent from 5.50 to 4.61 laid 3 times the ſame way from 9 *l.* 3 Ounces on the ſame line of Numbers, gives 5 *l.* 6 Ounces the weight of Powder for ſuch a Gun to uſe in ſervice.

But if this Gun is ſtronger fortified, as the *Dutch* 12 Pounder is, it will bear a greater Charge, and then the extent from 4800 to 3000 the weights of the whole Culvering,

and

and 12 Pounder will reach from 9 *l.* 3 Ounce the Culverings Charge to 5 *l.* 12 Ounces the 12 Pounders Charge.

But having found the Charge by the Diameter of the Bore. Then consider the fortification and weight, and by the line of Numbers say, as the weight or fortification the Gun should have to the Charge of Powder for such a Gun, so is the weight of the Piece found, to his fit Charge to be used.

But for this matter of weight of Powder, the Lines on the Rule described in the second Use, are sure Directions, and as ready and easie as ever was used; done by *Thomas Binning*.

CHAP. XV. or II.

The Description and Use of a convenient Horizontal, Vertical, or South Erect Dial, for any one Latitude, or an Equinoctial Dial for any Latitude.

IT is a square Box of any convenient bigness, as from 2 or 3 Inches to 9 or 12 Inches square, in the lower part of which is a hole turned of any convenient bigness, for a Mag-

netical Needle to play in, with the 360 Degrees on a Brass Ring, or on part of the wood, for the Needle to point directly against, besides the 360 Degrees on the bottom of the Chard; being covered with glass and a wire, or wax to keep it from wet and wether.

To this Box is fastned a cover to open with Brass Hinges, and a brace to set the cover upright, or to any degree of elevation. Also a silk or lute-string thred to serve for a Gnomon, fastned to a piece of Brass at one end projected over the glass, and through a hole in the lid remote from the Hinges, serving for a stile to the Horizontal and South-Dial made for any one particular Latitude required.

Also on the superficies of the Box is delineated a Horizontal Dial for any one Latitude, and on the inside of the lid a South Dial for the same Latitude, and within this an Equinoctial Dial for any Latitude, also the same Equinoctial Dial to any Latitude, on the outside to 24 Hours, on the inside to 12 Hours, which is always enough.

The

The uses of the Instrument.

1. *To find the hour of the day by the Horizontal or South Dial, in that Latitude those are made for.*

Open the lid of the Box Square, by puting the open hole at the end of the brace over the upper pin in the edge of the Box Cover, then drawing the thred for the stile straight, make it fast by turning it once or twice over the pin, and into the cut on the upper corners of the lid.

Then set the Box down on any flat superficies, as the grass or the earth, or a Stone, as far from Iron as you can, so as no Iron be within 6 Inches of it, and set it as level as you can, which the needles playing levelly and well will shew.

Then turn the whole Box gently about, till the Needle play right over the Meridian line, that is the cross-end of the Needle right over against the Flower-deluce, then the Sun shining, the shadow of the thred shall

ſhew on the Horizontal Dial the hour required, and alſo on the South Dial for the moſt part of the day in Summer and all the day in Winter.

2. *To find the Magnetical Azimuth of the Sun viz. How many Degrees the Sun is from the Magnetical Meridian.*

Open the Box lid ſquare, and draw the thred ſtraight, and ſo keep it by the pin and cut in the corner of the lid; then ſet the Box down, or hold it ſteadily and level; being ſo ſet, turn it till the ſhadow of the thred cut the 12 a Clock hour line. Then the needle playing well and ſettled, ſhall on the Degrees ſhew the Suns Magnetical Azimuth required by the North end of the needle where the croſs is.

3. *To find the variation of the Needle from the true Meridian.*

When the Sun is in the Meridian, which is every day at 12 a Clock, make the ſhadow of

of the thred to cut juſt 12; the Box ſtanding level, and the Needle playing well, then what the Needle wants of playing juſt againſt 0 Degrees is the variation, and the Degrees ſhew which way; *viz.* Eaſt-ward or Weſt-ward.

But this way, though it be very plain and eaſie, yet it being difficult to know when it is 12 exactly, another way may be thus, At any time of the day, at an hour at leaſt before or after noon, open the lid and ſet the Box lid ſquare, and draw the thred ſtraight, and ſet it down level, and make the ſhadow of the thred to cut the line of 12. Then by the former Rules Page 95 find the Suns true Azimuth by the Triangular Quadrant, by the Suns Altitude; and juſt when you take the Suns Altitude to find the Suns Azimuth, ſee that the Shadow cut 12, and that the Needle play well, and note on what degree it cuts, which is the Magnetical Azimuth, and then the difference between that and the true Azimuth is the variation of the Needle.

Example,

Example, suppose on the 11*th* of *June* in Latitude 51,30 the Sun being 45 degrees and 42 minutes of Altitude at 9 in the fore-noon, the Box standing level, and the thred cutting 12, the Needle at the same time cuts 64 degrees 20 minutes, but the Suns true Azimuth found by the rules in page 95 is 68.40. Then consider the Suns Azimuth being more then the Magnetical Azimuth, the Needle will play on 0 degrees or the North point, before the Shadow of the Thred will fall on 12, therefore the North or cross end of the Needle varieth to the West-ward, and Substraction being made, *viz.* 64.20 taken from 68.40 remains 4.20 for the variation of the North end of the Needle Westward.

4. *To find the variation in a Morning or Evening at the Suns very Rising or Setting, called Amplitude.*

On the 10th of *March* or 13th of *Septemb.* when the Sun riseth in the East and sets in the true West point of the Horizon; set the Box down on a flat place, open the lid and straighten the thred, and look through the middle hole, turning the Box till the

Thred

Thred looking through the Center hole in the Box lid, cut the middle of the Sun just at rising, half being above the Horizon, then if the Needle cut the East and West line there is no variation, if not, so many degrees as it differs is the variation, and which way the Card and Needle will shew, with a little due consideration.

Note, That at any other day you must find the Suns Amplitude by the rules in page 93, and the difference between that and the Magnetical Amplitude shewed by the Needle is the variation.

Note, When the observed true Suns Amplitude, counting from the East point, is nearer to the North then the Magnetical Amplitude shewed by the Needle, the variation is West-ward.

If the true Amplitude be nearer the South part of the Meridian then the Magnetick Amplitude, the variation is East-ward; and count contrarily in the afternoon at Sun-setting.

5. To find the true hour of the day.

The quantity of the variation being known how much and which way, then the Needle Point is to play right againſt ſo many degrees at each end, and then the Shaddow of the thred will ſhew the true hour of the day on the Horizontal and Vertical Dial.

6. To find the hour of the day in any Latitude.

Put the hole in the end of the Brace over the lower Pin in the edge of the Box lid, and ſhut the Box lid till the innermoſt edge of the Box lid cut the Degree of Latiude on the Brace; then the Box ſet flat and level, and the Needle Point playing right over the Degree of Variation, the Box is ſet due North and South, and the Box lid is parallel to the Equinoctial Circle, and a ſmall fit Pin ſtuck in the Center hole repreſents the Axis, and points up to the North Pole; and the Shadow of that Pin will ſhew on the upper ſide of the Box lid, in Summer time the true hour

hour of the day required in that Latitude it is to ſet to.

In the Winter time the Dial on the inſide is only in uſe, ſticking the Pin in the Center on the inſide.

7. To find the Declination of a Wall by the Needle.

Apply the Box lid flat to the Wall, and hold the Box level, then the Needle being ſettled ſheweth the Declination, conſidering it thus. If the Croſs or North end of the Needle be next the Wall, it is a Plane beholding the South. Then if the North is before you, the Eaſt is on the right hand, and the Weſt on the left; then if the Sun being in the Eaſt point can look on the Plane, it is South Eaſt, if not it is a South Weſt Plane.

But if the South end of the Needle be next the Wall, it is a North Plane, and the Weſt then is on the right hand; then if the Sun being in the Weſt can look on it, it is a N. Weſt Plana, otherwiſe a North Eaſt Plane.

The

The Needle ſhewing how much when you have rightly Added or Subſtracted the Variation.

In South Eaſt Decliners add the Variation to what the Needle ſhews, the Sum is the Declination South Eaſt, in South Weſt Decliners ſubſtract the Variation from what the Needle ſheweth, then the remainder is the Declination of the Plane South Weſt.

8. *To find the Coaſt of any Country.*

Set the Box down flat, ſo as the Needle may play freely and well, and turn the Box till the North end play over the Flower-deluce, then the Box and Lid lieth North and South; the two Hinges lie Eaſt and Weſt, and the Compaſs at the bottom ſhew alll the other points in their true Situation.

9. *To*

9. *To find the Suns true Azimuth.*

Open the Box lid and ſet it upright by the Brace, and draw the Thred ſtraight and faſten it; then turn the Box till the Shadow of the Thred play on the true hour of 12, then the Needle point ſheweth the true Azimuth when you have diſcounted the Degrees of Variation.

10. *To find the hour by the Hour line on the Card.*

The Box being opened and ſet as in the laſt was mentioned, *viz.* The Shadow of the Thred playing on 12, then the North end of the Needle in Summer time cuts the hour on the lines on the Card, according to the Declination of the Sun, found right againſt the day of the Month, expreſt between XII and XII by the Flower-deluce.

And in the Winter time it cuts the hour of the day in the Circle of Declination, ſhewed by the Months between 12 and 12

at the South end of the Card by the South end of the Needle.

This projection is made properly for the Latitude of 51 deg. 30 min. of North Latitude, and may serve near for two Degrees more or less then 51 deg. 30 min.

FINIS.

The USE OF A SLIDING-RULE, To Measure Board or Timber Measure.

THe Lines on one side of the Rule is the ordinary Line of Numbers, cut on both sides to slide one by the other, to work Questions of a single Proportion, as the *Rule of Three*, *Multiplication*, and *Division*, &c.

The Lines on the other side of the Rule is a double Line of Numbers (or a Line of Numbers twice repeated, being the same as was on the other side of the Rule) set on one Piece, and on the other Piece next to it to slide by it a single Line of Numbers of one Radius, equal in length to the other two Radiusses, which is sometimes divided into 12 parts, to represent the Inches in a Foot, then called a *Whites Rule*, because of his first contrivance, though since much altered by *T. B.* But most commonly it is divided into Decimal Parts, and then of good use for

Gaugers, or any other double Proportions.

Also on the edges and out-sides is set Inches and Foot Measure, Timber, and Board Measure, or any Lines else you please, to take dimensions under or above 1 Foot, or to give the length of a Foot at any breadth.

But on ordinary *Glasiers Rules*, who use only single Proportion, the single Line to one Radius only, is set on one side, and a broken Line on the other side, to supply the defect of the other; and to make the Line as large as it may be on Foot Rules, their usual size of length; being two Foot near, or two Foot just, when pulled to the utmost extent.

Thus much for Description of the Three sorts, the Uses follow.

CHAP. I.

Sect. 1. *First for the Ordinary Glasiers Sliding Rule in Numeration.*

IF you slide the Rule out to its full length with 1 on one single Line to be just against 1 on the other single *Line*, then on the two Pieces you have the same double Line, to use with Compasses as is described in the former part, and the reading

ing is the same as on the former, therefore needs no repetition as to Numeration, on this, and the broken Line on the other side is the same, as afterwards in the working you will plainly see.

Sect. 2. *Of Multiplication by the* Sliding Rule.

Set 1 on any side (which for method sake may be) called the first side to the *Multiplicator* on the other side (calling it the second side) then right against the *Multiplicand* found on the first side, is the product on the second.

Example. Let 29 *be multiplied by* 45.

Set 1 on the first side to 45 on the second side, then right against 29 found on the first side, is 1305 on the second side the product.

Now to direct you to the right number of places, observe that there will be as many figures in the Product as in the Multiplicator and Multiplicand, as here in this *Example* 1305, four figures, as many as is used to express 29 and 45, the two first figures of 1305, *viz.* 13 being less than 29 or 45. But when the two first figures of the Product are more than the Multiplicator or Multiplicand, then there is one figure less.

Example, Let 81 *be multiplied by* 12.

Set 1 on the first side to 12 on the second, then just against 81 on the first side is 972 the product; consisting of but three figures, because 97 the two first figures of the Product, is more than 12 or 81 the two first of the Multiplicator or Multiplicand.

Again, let 136 be multiplied by 19, set 1 on the first side, to 19 on the second, then right against 136 on the first is 2584, of four figures only, because 25 is more than 13 or 19.

Now to hit the last figure right, consider that 9 times 6 is 54, therefore 4 is the last figure, and the Rule sheweth the first 3 to be 258 certainly, and the last figure is found by multiplying the two last by ordinary Multiplication, a good help sometimes.

Note, When the third Number falls beyond the end of the Rule, seek it on the other side, calling the same side or piece of the Rule, the first, as you did before.

Example, Let 42 *be multiplied by* 36.

Set 1 to 36, then right against 42 found on the other side, yet on the same first Piece that 1 was on, on the second is 1512 the product required to be found

of

of so many figures, and 2 the exact last figure by the last Rule found, viz. 2 times 6 is 12.

Sect. 3. *Division by the Sliding Rule.*

Set the Divisor found on (any) first side to 1 on the second: then just against the Dividend found on the first, is the Quotient on the second side required.

Example, Let 360 be divided by 12.

Set 12 on the first side, to 1 on the second, then just against 360 on the first is 30 on the second, the Quotient, for 12 times 30 is 360.

Again, Let 157 be divided by 20.

Set 20 to 1, then just against 157 is $7\frac{17}{20}$, the Quotient. Then if you seek $\frac{17}{20}$ on the second side, on the first is 17 the Vulgar Fraction remaining, for in 137 *l.* is 7 *l.* 17 *s.* The number of Figures in the Quotient is as many as the Dividend exceeds the Divisor, when the first figure of the Divisor is greatest; as thus to divide 12521 by 15, the Quotient is $834\frac{11}{15}$.

But to divide 9258 by 17 the Quotient is $560\frac{18}{17}$ of one figure more than the Dividend exceeds the Divisor.

Or always as many Figures as set times under the Dividend, in the usual way of Division by the Pen.

Sect. 4. Of Reduction by the Sliding Rule.

Set one Denominator counted on the first side, to the other Denominator on the second side, then just against the given Numerator on the first side is the inquired Numerator on the second.

Example. In 125 *Ells how many Yards?*

Note, that 5 quarters of a Yard is one Ell, or 45 Inches is one Ell, and 36 Inches is one Yard; set 4 on the first side, to 5 on the second, then right against 125 on the first, is 156 Yards and a Quarter the Answer to the Question, the Ells being reduced to Yards.

Or you may say as 36, the Inches in 1 Yard, to 45 the Inches in 1 Ell, so is 125 to 156.

Again, in 593 Inches how many Feet? Set 1 the one Denominator to 12 the other Denominator, then just against 593 one Numerator, for the Inches is 49 Foot, and 5 Inches over, the other Numerator for Feet.

Sect. 5. Of the Rule of Three Direct.

After you have prepared your three Terms if need be by Reduction, Then the Rule is thus, Set

Set the first Term, being of the same Denomination as the third Term (or the Term of Demand) is, to the remaining term being the second, then right against the third term is the fourth term required.

Example, *If one Foot of Glass cost* 5 *d. what cost* 29 *Foot and* $\frac{1}{2}$?

Here you see the Term of Demand is $29\frac{1}{2}$ Foot of Glass the third term, then 1 Foot of Glass being of the same Denomination is the first Term, then 5 *d.* the remaining Term must needs be the second.

Then set 1 on the first side to 5 on the second, then right against $29\frac{1}{2}$ on the first, is $147d.\frac{1}{2}$.

Or by the Line of Numbers and Line of Pence annexed, set 1 on the Line of Numbers to 5 *d.* on the Line of Pence; then just against $29\frac{1}{2}$ on Numbers, is 6, for 12 *s.* and 146 over, which Fraction sought on the Line of Numbers, just against it on the Line of Pence is 3 Pence 2 Farthings.

Again, *If* 3 *Yards and a half of Cloth cost* 28 *s. What shall* 9 *Yards three quarters cost?* Set 3 and $\frac{1}{2}$ to 28, then just against $9\frac{3}{4}$ found on the same side that 3 was is 78 *s.* the Answer, found on the second side.

Sect. 6. *Of the Rule of Three Reverſe.*

Set the firſt term counted on any ſide to the ſecond, being of the ſame Denomination on the other ſide; Then ſeek the third term on the ſecond ſide, and right againſt it on the firſt is the anſwer required.

Example, If 12 men dig a Celler in 24 Hours, how many men may dig the like Celler in 8 Hours?

Set 24 on one ſide to 8 on the ſecond ſide, then juſt againſt 12 on the ſecond ſide, is 36 on the firſt ſide, the Number of Men required.

Sect. 7. *Of the Double Rule of Three Direct.*

To perform this Rule, you muſt uſe two workings of the ſingle Rule.

Example, If the Increaſe of two Buſhels of Wheat in one Year be 24 Buſhels, what ſhall the increaſe of 6 Buſhels be in 5 Years.

Set 2 on the firſt ſide to 24 on the ſecond, then right againſt 6 on the firſt ſide is 72, the increaſe of 6 Buſhels in one Year.

Then ſet 1 on the firſt ſide to 72 on the ſecond, then right againſt 5 on the firſt ſide,

ſide, is 360 on the ſecond, the increaſe of 6 Buſhels in 5 Years required.

Sect. 8. *To meaſure or caſt up Board or Glaſs, or any ſuperficial meaſure.*

Prob. 1.

The breadth of any Board or Glaſs given, to find the length to make 1 Foot.

1. If the breadth be given in Inches, ſet 12 on any one ſide, to the breadth in Inches on the ſecond; then right againſt 12 on the ſecond ſide is the Number of Inches required, as in the back *Rule of Three*, or as 8 to 12 ſo is 12 to 18 forwards.

Example, At 8 Inches broad, how much in length makes 1 Foot?

Set 8 on one ſide to 12 on the ſecond, then right againſt 12 on the firſt ſide, is 18 Inches on the ſecond ſide, the length required to make one Foot.

But if the breadth be given in Foot-meaſure, then ſet the breadth in Foot-meaſure to 1, then juſt againſt the other 1 is the Anſwer in Feet and 100 parts required. *Example*, At 0.80 broad, ſet 0.80 to 1, then juſt againſt the other 1, is 1.25 the length to make one Foot.

2. *At*

2. *At any breadth given, to find how much is in a Foot long.*

If the breadth be given in Foot Measure, then just as the Rule stands even, *viz.* 1 against 1, *&c.* seek the breadth given on any one side, and just against it on the other is the Answer in Decimals or Feet and Decimals.

Example, At 2.50 broad, just against 2.50 on one side is 2.50 on the other for 2 Foot and ½ the Answer.

But if the breadth be given in Inches, then set 12 on any side to 1 on the other, then right against the Inches broad counted on the first side is the tenths or feet, and tenths contained in a Foot long.

But if you count the Inches broad on the second side, on the first is the Superficial Inches contained in one Foot long.

Example, At 6 Inches broad, how much is in a Foot long?

Set 12 to 1, then just against 6 on the first side is 5 tenths or half a Foot the answer.

Also (at the same setting) right against 6 the breadth counted on the second side, is 72, on the first side the Superficial Inches contained in a piece of Board or Glass

of

of 12 Inches long and 6 Inches broad

3. *The length and breadth given, to find the superficial content.*

1. *First, The length and breadth given in Foot Measure.*

Set 1 on any side to the breadth on the second, then right against the length counted on the first is the answer on the second.

Example, At 1.15 broad, and 5.45 long, as 1 to 1.15, so is 5.45 to 6.27.

2. *The breadth given in Inches, and the length in Feet, then find*

Set 12 to the breadth in Inches on the second side, then right against the length in Feet counted on the first, is the content in Feet required.

Example, At 20 Inches broad, and 4 Foot 6 Inches long.

Set 12 on one side, to 20 on the other, then just against 4 Foot and ½ on the first is 7 Foot and ½ the superficial Contents.

3. *When*

3. *When the breadth and length is given in Inches, to find the Content in Inches, Then say:*

As 1 to the breadth in Inches, so is the length in Inches, to the Content in superficial Inches. *Example*, At 15 Inches broad and 40 Inches long, set 1 to 15, then just against 40 is 600.

4. *Or to find the Content in Feet, having the length and breadth in Inches.*

Set 144 to the breadth in Inches, then right against the length in Inches, is the Content in Feet. *Example* as before.

Set 144 to 25, then right against 40 is 4 Foot 2 Inches, the Answer.

5. *Having the length and breadth in Feet and Decimals, to find the Content in Superficial Yards.*

Set 9 to the breadth in Feet, then right against the length in Feet is the Content in Yards. *Example*, At 15.30 broad, and 26.80 long, how many Yards?

Set 9 to 15.30, then just against 26.80 is 45 Yards and $\frac{1}{3}$, and so for any Superficial Measure of any kind.

Sect. 9. *To measure and cast up Solid or Timber Measure by the Glasiers Sliding Rule.*

This single Line is not so ready for measuring Timber, as to be used with Compasses, because of a double Operation; yet it may be done in this manner either by Foot Measure or by Inches, according as you take the Dimensions.

1. *The side of the Square given in Foot Measure, to find how much in length makes one Foot.*

Set the Feet and 100 parts square to 1, then just against the other 1 is a fourth Number, which fourth Number sought on the first side, right against it on the second is the answer.

Example, At 0.666 (or 8 Inches Square) how much makes 1 Foot?

Set 0.666 to 1, then just against the other 1, is 1.50, a fourth, then as the Rule stands, just against 1.50 on the other side, is 2.250 on the second side, for 2 Foot $\frac{1}{4}$ the length required in Foot Measure to make 1 Foot.

But if the side of the Square be given in

in Inches, that is done also in the same working, using 12 instead of 1.

For just as 0 666 stands against 1, Inches stands against 12, then just against the other 12 is 18 the 4th.

Then 18 sought on the first side, on the second is 27 Inches, the true length to make 1 Foot of Timber at 8 Inches square.

2 *The breadth and thickness given in Foot Measure or Inches, to find how much in length makes a Foot solid, without Squaring.*

Examples, At 9 Inches thick, and 14 Inches broad.

Set 12 against 9, then just against 14 on the first, is 10 48 for a fourth: then set the fourth, *viz.* 10 48 to 12, and right against the other 12, is 13 Inches 74 parts the length required.

Note, The very same Work serves for Foot Measure also, for when 12 is set to 9 Inches 3 quarters of 12, then 1 is just against 75, which is 3 quarters of 100, and so in the second working also.

3. *The side of the Square given, to find how much is in a Foot long?*

Set the Inches Square to 12, or the

De-

Decimals Square to 1, which is done both at once, then just against the Inches square on the second side, on the first is the quantity in Inches, or just against the side of the Square in Decimals is the feet and 100 parts contained in one Foot long. *Example*, At 18 Inches or 1.5 *Square*, how much is in one Foot long.

Set 18 to 12, or 1.5 to 1 (which will be done at once) then just against the other 1.5 is 2.25, for 2 Foot $\frac{25}{100}$ the Answer.

But if the breadth and thickness be given; then to find how much is in a Foot long: Work thus, *Example*, At 9 Inches thick and 15 Inches broad: Set 12 on the first to 9 on the second, then just against 15 on the first, is 11 Inches 23 parts.

Or against 1.25 in Decimals, is 0.938 the exact quantity of Timber in one Foot long: which multiplied by the length of the Tree or Plank, gives the Content in Feet required; this is as certain a way as any other.

4. *The Side of the Square given in Inches and the Length in Feet, to find the Content in solid Measure.*

Example, At 9 Inches square and 20 Foot long.

Set 12 to 9, then right against 20 is 15 a fourth.

Then seek the same 15 on the first side, and just against it on the second is 21 Foot and ¼ the Content.

Note, The same work performs it by Foot Measure also; for when 12 is against 9, 1 is against 75 equal to 9.

5. *But if the Piece be not Square, then work thus.*

Example, At 18 Inches thick, and 27 Inches broad, and 20 Foot long.

Set 12 to 18, then just against 27 is 40 5 a fourth: Again, set 12 to 40.5, then just against 20 the length is 67 Foot ½ the Content.

This is the most used Proportion in Measuring of Square Timber, but if the Diameter of a Round Piece be given, then use 13.54 which is the Diameter of a Tree, when one Foot long makes one Foot of Timber, or 1.128 when you use Foot Measure, for as 12 is to 1, so is 13.54 to 1 128.

If

If the Circumference of a Tree be given, then use 42.54 the Inches a Tree is about, when one Foot long makes 1 Foot, or 35.45 for Foot Measure, as you may find it largely worded from page 232 to 242 of the *Triangular Quadrant*, and in the following Uses of the *White's Sliding Rule.*

But of these two Points 13.54 for the Diameter, and 42.54 for the Circumference in two *Examples*,

If the Diameter of a Tree be 20 Inches, and 22 Foot long.

Set 13.54 to the Inches Diameter 20, then just against 22 Foot the length, is 32.40 a fourth, which sought on the other side, sheweth 48 Foot the Content on the second side.

Also if the Circumference or Girt be given, then thus, *Example*, At 63 Inches about, and 22 Foot long.

Set 42.54 to 63 the Circumference about, then just against 22 the length is 32.5 a fourth, which sought on the other side, just against it on the second is 48 Foot the Content required; thus much for the *Glasiers Rule* and for all the other on one side.

CHAP. II.

The Use of Mr. White's *Rule for Measuring Timber.*

ON the furthest side from you, or on the left side, is a Double Line of Numbers, on the neareſt or right side is a ſingle Line of Numbers, whoſe Radius from 1 to 10 is juſt as large as the other from 1 to 100. The Figures on each ſide from 1 to 100 on the far ſide, and from 1 to 10 on the near ſide repreſent ſo many Feet, and the cuts between repreſent Inches, Halfs, and Quarters, as far as they can be ſo divided: The figures before 1 on both ſides are Inches only with Halfs and Quarters between.

The Mark at T. D. ſerves for the true Diameter of any round thing; the Mark at D. takes in the allowance, when you count the fourth part of the Girt the ſide of the Square equal.

The Mark at T. R. and at R. is the ſame, uſing the Circumference of any round thing. Thus much for the Deſcription, the Uſes follow.

1. *To*

1. *The breadth and thickneſs given, to find the ſide of the Square equal.*

Set the thickneſs on the right ſide to the ſame on the left, then juſt againſt the breadth counted on the left ſide, on the right ſide is the ſide of the Square equal required. *Example*, At 9 Inches thick and 16 broad, ſet 9 Inches to 9 Inches on each ſide, then juſt againſt 16 on the left ſide is 1 foot, or 12 Inches on the right, the ſide of the Square equal; for 9 times 16, or 12 times 12 is 144.

Or if you ſet the breadth on each ſide together, then right againſt the thickneſs counted on the left ſide, on the right is the ſide of the Square equal. *Example*, At 22 Inches broad, and 10 Inches thick, ſet 22 Inches or 1 foot 10 Inches on each ſide together, then juſt againſt 10 Inches on the left, is 14 Inches $\frac{1}{4}$ and $\frac{1}{7}$ the ſide of the Square equal.

2. *The ſide of the Square given, to find how much is in a foot long.*

Juſt as the Rule ſtands even, *viz.* 1 and 1, 2 and 4, 3 and 9 even, ſeek the ſide

of the Square on the right or near side, and just against it on the left is the Answer required. *Example*, At 17 Inches square, 1 foot long is two foot of Timber, at 28 Inches square, there is 5 foot and 5 Inches in a foot long; and at 9 Inches Square, but 6 Inches 3 quarters in one foot long.

At 3 Inches and $\frac{1}{2}$ Square, but one Inch in a foot long, found at the beginning of the lines: Or calling 3 foot and $\frac{1}{2}$ on the right side 3 Inches and $\frac{1}{2}$, on the left side is a small figure 1 at 12, now noteing but 1 Inch.

At 2 Inches square counted at 2 foot on the right side, is four on the left, noteing now four twelfth parts of 1 Inch when 12 is but one Inch, *&c.*

3. *The side of the Square given in Inches, to find how much in length will make one foot of Timber.*

Set the Inches, or Feet and Inches square, found out on the right side, to 1 foot on the left; then just against 1 foot on the right, on the left is the length required to make one foot of Timber or solid Measure.

Example, At 5 Inches ſquare, ſet 5 on the right, to 1 on the left, then juſt againſt 1 on the right is 5 foot 9 Inches $\frac{1}{8}$, the length to make one foot.

Or ſet the Feet and Inches ſquare to ſmall 12 at 144 on the left, then right againſt 1 on the right, is the Inches and 12 parts required on the left, calling the ſmall figure at 12, 1 Inch, 2 at 24, 2 Inches; 3 at 36, 3 Inches; 4 at 48, 4 Inches, *&c.*

If the ſide of the Square be under 3 Inches, call 3 foot on the right 3 Inches, 2 foot 2 Inches, 1 foot 1 Inch, *&c.* And ſet that againſt ſmall 12 at 144, then right againſt 1 on the right, is the feet in length required to make 1 foot of Timber. *Example*, At 2 Inches and $\frac{1}{4}$ Square, ſet 27 Inches, or 2 foot 3 Inches to 144, then right againſt 1 on the right is 28 foot 4 Inches $\frac{1}{3}$, the length to make 1 foot.

Or at the ſame time, at 27 Inches ſquare, is 2 Inches and near $\frac{4}{12}$ and a half, the length to make one foot ſolid, counting the 2 Inches at the ſmall 2 (at 24) on the left.

4. *The side of the Square given in inches, and length given in feet, to find the content.*

Set 1 on the right to the length on the left, then just against the Inches, or feet and inches square on the right, on the left is the true content required. *Example*, At 20 foot long and any Inch Square, to find the content required.

Set 1 foot on the right side, to 20 foot on the left, then at 18 Inches square, is 45 foot of Timber, at 4 Inches square is 2 foot 2 inches and $\frac{1}{2}$, at 2 foot square is 80 foot, at 3 Inches square is 15 Inches, being read among the small figures, at 2 Inches square read at 2 foot on the right, is 6 Inches and $\frac{1}{2}$ on the left, among the small figures, this takes in the smallest of Timber.

But for very great Stones or Timber do thus:

Set 1 to the length in the first radius on the left, calling 1 foot 10 foot, 2, 20 foot, and then just against the Inches square is the Answer, calling 20, 200; 40, 400, *&c.* *Example*, if a Piece of Timber be 40 foot long and 40 Inches square,

Set

Set 1 on the right to 4 on the left, calling it 40, then just against 3 foot 4 Inches (or 40 Inches) square is 445 foot the answer or content required.

Sect. 2. *To Measure round Timber by the* Whites *Rule.*

1. *At any Diameter given, to find how much is in a foot long.*

SEt the mark at *t d* to 1 foot on the left, then just against the Inches or feet and Inches Diameter counted on the right, on the left side is the feet and Inches contained in 1 foot long.

Example, At any inch Diameter what soever, under 15 foot.

Set *t d* to 1, then right against 2 foot Diameter counted on the right is 3 foot 1 inch $\frac{1}{2}$, the solid Measure in 1 foot long, which being multiplied by the length of the Tree, gives the exact content.

At 8 foot Diameter is 50 foot in 1 foot long, but if you call 8 foot on the right but 8 inches, then the small figures *viz.* 4 at 48, shews but 4 inches and $\frac{4}{12}$, the exact Quantity of Timber in 1 foot long. Which you may see at the beginning and also among the inches.

Note, When you account the fourth part of the Girt the side of the square equal, then use the mark at *D* instead of *t d*.

2. *At any Diameter given, to find how much in length makes* 1 *solid foot.*

Set the inches, or feet and inches Diameter, counted on the right side, to 1 foot on the left, then right against the mark at *t d* for True Measure, or *D* for the Allowance, is the length required to make one foot.

Example, At 11 inches Diameter, set 11 to 1, then just against *t d* is 18 inches $\frac{1}{8}$, the length to make 1 foot.

When the Diameter is above 3 foot, set the Diameter to small 12 at 144 on the left, then just against *t d* is the inches among the small figures, and 12th part of an inch more to make 1 foot. *Example*, At 7 foot Diameter, set 7 foot on the right, to 144 (at small 12) on the left, then right against *t d* is $\frac{1}{12}$ of an inch and $\frac{2}{12}$ of a 12th to make 1 foot; but for very small wood under 4 inches Diameter, call 2 foot on the right 2 inches. *Example* At 2 inches Diameter, set 2 foot on the

right

right to 144 on the left, then just against *t d* is 45 foot $\frac{3}{4}$, the length required.

3. *The Diameter and length given, to find the solid content.*

Set *t d* to the length, then just against the Diameter is the solid content required. *Example*, At 26 inches Diameter and 25 foot long, set *t d* to 25, then just against 26 inches is 91 foot and $\frac{1}{2}$, at three inches Diameter, is 14 inches and $\frac{8}{12}$ the content.

When the length exceeds, call 1 foot on the left 10 foot, *&c* as before in the square Measure, and the content increase by 10 also.

Sect. 3. *To Measure round Timber by having the Circumference.*

1. *At any Circumference given, to find how much is in a foot long.*

Set the mark at *t r* for true Measure, (or the mark at R for the Allowance or Custom as above said) to 1 on the left, then just against the inches about, is the Quantity in one foot long, which being multiplied by the length in feet, gives the true solid content. *Example*,

Example, At 2 Foot about, set *tr* or *R* for true Measure or Customary, to 1 Foot, or 12 at 144 on the left; then just against 2 Foot, is 3 inches and $\frac{2}{12}$ the content in a Foot at true Measure; or if you set *R* at 4 to 144, then against 2 foot is just 3 inches in a foot, shewed by the small 3 at 36.

But if you call 2 foot but 2 inches, then the 3 is but $\frac{1}{144}$ of 1 Inch in a Foot long.

2. *The Circumference given, to find how much in length makes* 1 *Foot.*

Set the Inches or Feet and Inches about, to 1 foot on the left, or to 144, then just against *tr* for true Measure, or *R* for the Allowance, is the length to make one foot.

Example, At 5 Foot about, set 5 Foot to 144, being most convenient, then just against *tr* is 6 Inches and $\frac{1}{12}$, the length to make a Foot at true Measure, or right against *R* is 7 Inches $\frac{2}{12}$ to make a Foot at the usual Allowance.

Note, At the same time as 5 Foot on the right stands against small 12 at 144 on the left; 5 Inches at the beginning end stands against 1 Foot on the left, and just against *tr* is near 72 foot and $\frac{1}{2}$, the length to make 1 Foot at true Measure,

or

or 92 Foot against the usual Allowance.

3. *The Circumference and length of a Tree, given in Feet and Inches, to find the Content in solid Feet.*

Set the Mark at *t r*, or *R*, to the length, then just against the Inches, or Feet and Inches about, is the Solid Content in Feet and Parts. *Example*, At 3 Foot 3 Inches and $\frac{1}{2}$ about, and 30 Foot long, how much Timber is it?

Set *t r* to 30 Foot the length, then just against 3 Foot 3 Inches and $\frac{1}{2}$, is 25 Foot 10 Inches the true solid Content.

But if you set R to 30 Foot, then against 3 Foot 3 Inches and $\frac{1}{2}$, is but 20 Foot 4 Inches.

Thus you may measure any Square or Round Body, for other forms reduce them to Square or Round.

To reduce Feet into Beer or Ale Barrels, observe, 5 foot 875 parts is a Beer Barrel (or allowing for waste, say 6 Foot) 5 Foot 233 parts is an Ale Barrel, 0.1631 is an Ale or Beer Gallon, 0.1337 is a Wine Gallon; and what those Decimal Fractions are in Inches, the Inches and the Foot Measure, doth readily shew by Inspection only.

So

So that to gauge any Round or Square Veſſel, do thus:

By the Depth and Diameter meaſure it as a Piece of Timber or a Stone in feet and parts, then by the Double Line of Numbers, ſay, If 5.875 be one Barrel, what ſhall any other Number be?

Example, A Brewers Round Tunn is 5 Foot $\frac{1}{2}$ over in Diameter, and 3 Foot 2 Inches deep, ſet 1 *d* to 3 Foot 2 Inches, then juſt againſt 5 foot 6 inches is 75 foot. Then by the other ſide ſet 5.875 to 1, then juſt againſt 75 is 12 Barrels and 3 Firkins, the near Content in Beer Barrels.

The ſame manner of Work ſerves for any other Veſſel Round or Square; but of this more particulary by a Decimal Rule.

CHAP. III.

The Uſe of the Gangers Sliding Rule.

Sect. 1. *The Uſe of the ſingle ſide is largely ſhewed in the Firſt Chapter, what is to be added as appertaining to Gangers uſe follows in order.*

TO reduce Wine Gallons to Beer Gallons, and the contrary.

Note, That a Wine Gallon contains 231 Cube Inches, and a *Beer* or *Ale* Gal-

lon

282 Cube Inches, therefore set 282 on one side, to 231 on the other side, then just against any Number of Wine Gallons found on the side where 282 was counted, on the other side is the answerable Number of Ale Gallons, and the Number of Ale Gallons counted on the side where 231 was counted, just against is the Number of Wine Gallons required. *Example*, When 231 is set to 282, right against 300 Wine Gallons is 246 Beer Gallons; Again, on the contrary, 200 Beer Gallons is 244 Wine Gallons.

2. *To reduce any Number of Beer Gallons to Ale or Beer Barrels.*

Note, That 32 Gallons make 1 Ale Barrel, and 36 of the same Gallons make 1 Beer Barrel. *Example*, in 2572 Gallons, how many Ale Barrels? Set 32 to 1, then just against 2572, is 80 the Number of Ale Barrels, and 12 Gallons over.

Or if you set 36 to 1, then just against 2572, is 71 Beer Barrels and 16 Gallons over, being done by the Rule for Division.

On the contrary in 22 Beer Barrels and $\frac{1}{2}$, how many Gallons? Set 1 on any side to 36 on the other, then just against $22\frac{1}{2}$, is 810 the Gallons in 22 *Beer Barrels* and $\frac{1}{2}$.

3. *To reduce Ale Barrels to Beer Barrels and the contrary.* Set

Set 32 to 36, then just against 8 Beer Barrels, is 9 Ale Barrels, and just against 40 Ale Barrels, is 35 and ½ Beer Barrels, 800 Ale Barrels, is 710 Beer Barrels.

4 *To find the Excise due for any quantity of Gallons without allowance at any rate of Excise whatsoever.*

Note, The solid Excise for 36 Gallons of *Strong Beer*, as it went in 1683 without allowance of 25 *Barrels* for 20 was 2 *s.* 6 *d.* for 32 Gallons of Ale 2 *s.* 7 *d.* for 36 Gallons of *Small Beer* 0 6 *d.*

This being premised for any Number of Gallons under or above 36 (or 32 for Ale) to find the Excise due. *Example*, What is the Excise due for 24 Gallons of strong *Beer?*

Set 36 the Gallons in one Barrel, to 30 the Pence due for 36 Gallons, then just against 24 Gallons is 20 *d.* the Excise due for 24 Gallons.

Also at the same setting you have the Pence due for any greater or lesser Number of Gallons, as 3 Gallons is 2 Pence ½, 30 Gallons is 25 Pence, 72 Gallons hath 60 Pence, 180 Gallons hath 150 Pence, which is 12 *s.* 6 *d.*

5. *To find the Excise due for any Number of Barrels, with allowance.*

For Strong Beer set 23 for 23 Barrels on any one side, to 2*l.* 10*s.* the Excise on the other side, then just against any Number of *Barrels* found out on the first side, is the Excise due on the second. *Example*, What is the Excise due for 30 *Barrels* of *Strong Beer*? When 23 is set to 2.5, then just against 30 is 3.26. *Note*, The 3 is 3*l.* and the 25 more is 5*s.* and the 1 Tenth over counted on Numbers, on the Line of Pence is near 2*d.* 2*far.* in all 3*l.* 5*s.* 2*d.* 2*far.* the exact Answer.

For Strong Ale set 22 to 2.5. *Example*, At 70 *Barrels* of *Ale*, to find the Excise, with Allowance of two Barrels in 22. Set 22 to 2.5, then just against 70 is 7*l.* 19*s.* 0*d.* the Money due for 78 *Barrels* of *Ale*.

For *Small Beer* set 23 to 0.5. *Example*, What Excise is due for 60 *Barrels* of *Small Beer*? Set 23 to 05 the Excise due for 23 *Barrels*, then just against 60 is 1*l.* 6*s.* 0*d.* the Excise due for 60 *Barrels* of *Small Beer*.

Again, At 5 *Barrels* is 1.085. *Note*, The 1 is 2*s.* then just against 085 counted on the first Part of the Line of Numbers,

on

on the Line of Pence is 2 *d.* in all 2 *s.* 2 *d.* Again, for 8 *Barrels* is 1.735. *Note*, The 1 is 2 *s.* and 735 more counted on Numbers on the Line of Fence is 17 *d.* 2 *f.* in all, 3 *s.* 5 *d.* $2\frac{1}{2}$, the Exciſe due for 8 *Barrels* of *ſmall Beer*.

6. To reduce Round Veſſels to Square and the contrary.

Note, That any Round Veſſel whoſe Diameter is 10, the Circumference is 31.42, and the ſide of the Square equal to the ſame Circle whoſe Diameter is 10, is 8.862, and the inſcribed Square is 7.071, and the Area of ſuch a Circle is 78 54.

Therefore if the Diameter of a Circle be 20 Foot, how many Feet and parts is the ſide of a Square equal to it? Set 10 the fixed Diameter to 8.862 the fixed ſide of the Square equal, then juſt againſt 20 the given Diameter is 17.72 the ſide of the Square equal to ſuch a Circle whoſe Diameter is 20 Foot.

Or if you have a Square Veſſel, to find the Diameter of a Round Veſſel to be equal to it; ſet 8.862 the fixed ſide of a Square, to 10 the fixed Diameter; then juſt againſt the ſide of any other Square equal is the Diameter required; thus againſt

gainſt 17.72, is 20, as before.

The like work ſerves to find the inſcribed Square in a Circle; or the Circumference by having the Diameter, *&c.*

7. *Having the Diameter or Circumference of any Circle given, to find the Area.*

Example, at 15 Foot Diameter, what is the Area?

Set 10 the fixed Diameter to 15 the given Diameter, then juſt againſt 78.54 the fixed Area for 10 is 11.76 a fourth, which ſought on the other ſide is 176, the Area required.

Or having the Circumference given, ſet the fixed Circumference 31.42 to the given Circumference 47.25, ſo is 78.54 to 11.76 a fourth, which ſought on the other ſide, gives 176 as before.

Sect. 2. *The uſe of the other ſide of the Gaugers ſliding Rule.*

On this ſide, as before in the *Whites Rule*, one ſide is a double Line of Numbers of two Radiuſſes decimally divided.

The other ſide is a ſingle Line of one Radius, juſt as long as the other two Radiuſſes, decimally divided alſo, on which Line is placed ſeveral Gauge Points, for ſeveral uſes, as at 17.15 for Wine Gallons, 18.95 for Ale Gallons, 107.20 for

an Ale *Barrel*, at 113.69 for a *Beer Barrel*, at 1.128 for Cube Inches; all these Points are for Round Vessels, and the like may be for Square Vessels, as in page 89 of the *Practical Gauger* you may see more at large; whose use is thus:

1. *The Diameter and Depth of any Round Vessel given, to find the Content in Wine Gallons.*

Set 17.15 to the depth of any Round Vessel, then just against the mean Diameter found on the single Line, on the double Line is the Content required. *Example*, At 40 Inches deep or long, and 28 Inches mean Diameter: Set 17.15 to 40, then just against 28 is 107 Gallons the Content required.

Note, That the most usual way to find the mean Diameter in most ordinary Swelling Vessels may be thus; add two third parts of the difference between the Head and Bung Diameter, to the Head Diameter, or take one third part of thedifference from the Bung Diameter, and the sum or remainder shall be the Quotient Diameter of the Vessel required.

Example, Suppose the Bung Diameter be 33 Inches, and the Head Diameter be 24 Inches $\frac{5}{10}$, the difference found by subtraction

ſtraction is 8 Inches $\frac{1}{10}$, one third part of 8 Inches 5 is 2.835, which taken from 33.000, remains 30.165 for a mean Diameter, or two thirds of the difference, *viz.* 5.670 added to 24.5 the Diameter at Head, makes 30.17 a mean Diameter as before, and the length being 42 Inches.

Then by the laſt Rule, ſet the Gauge Point 17.15 to 42 Inches, the length on the double Line, then juſt againſt 30.17 the mean Diameter counted on the ſingle Line, on the double Line is 130 Wine Gallons, which is the mean content between 133 the greateſt as a Spheroid, and 132 the leaſt counted as a Conoid.

But to find this mean Diameter more readily and near the truth, count the difference of Diameters on inches, and juſt againſt it on the Lines called Spheroid, Parabola, Conoid, and Cone, is a Number to add to the Head Diameter, to make a mean Diameter. *Example*, As before, the difference is 8 inches and $\frac{1}{2}$, juſt againſt 8.5 on the Line of Inches, is 5.39 on the Line Parabole to add to 24.5 the Diameter at Head, which makes 29.89 a mean Diameter. Then as 17.15 to 42, ſo is 29.89 to 128 Wine Gallons the near Content of ſuch a Cask.

Note, This Line called Parabola, will be more used than the Line called Spheriod, or Conoid, it being the mean.

If you would have the Content in Ale Gallons, use the Gauge Point for Ale Gallons at 18.95.

2. *To find the Liquor wanting to fill a close Cask, or the Quantity of Liquor in a close Cask, having the Bung Diameter, and the full Content, and the dry or wet Inches.*

1. Set the Bung Diameter counted on Numbers, to 100 on the Line of Segments, then just against the dry or wet Inches counted on Numbers, on the Segments is a fourth Number, which remember.

2. Set Unites or 100 on Numbers, to the whole Content on the second side on Numbers, then just against the fourth Number remembred, counted on Numbers, is the Gallons wanting to fill the Vessel, or the Gallons in the Vessel.

Example, In the Vessel last mentioned, whose Bung Diameter was 33 Inches, and the Content when full 128 Wine Gallons, at 9 Inches dry or 24 Inches wet, how many Gallons is wanting? Or how many is in?

Set

Set 53 the Bung Diameter on Numbers to 100 on Segments, then just against 9 on Numbers, is 20 on Segments to remember for the Gallons wanting, and right against 24 the wet Inches, is 80 on the Segments, to remember, for the Gallons in the Veſſel.

Then having a pair of Compaſſes, the extent from 100 to 128 the full content, ſhall reach from 20 the Number remembred, to 25 Gallons $\frac{6}{10}$ the Gallons wanting, or from 80 the Number remembred, for the wet Inches, to 102 Gallons $\frac{6}{10}$, the Gallons in the Veſſel, at 24 Inches wet.

Note, The uſing of Compaſſes ſaves the removing the Sliding Rule, and you may make a Table for any Veſſel at any Inches or parts dry, as faſt as another can write it down.

3. *To Meaſure Brewers Round Tuns by the Sliding Rule.*

The contents of great Tuns, round or ſquare, is uſually given in Barrels, Firkins and Gallons. Then,

Set the page point for Ale or Beer Barrels always to the depth of the Tun in Inches, counted on the double line of Numbers; then juſt againſt the mean

Diame-

Diameter counted on the ſingle Line of Numbers, on the double Line is the content in *Barrels*; and the decimal parts over reduced, gives the Firkins and Gallons over.

Example, Let the greater Diameter be 70 Inches, and the leſſer Diameter 60, the ſum is 130, the half ſum is 65; (to which add $\frac{1}{10}$ makes 65 Inches, 6 Tenths, a mean Diameter for ſuch a Conical Veſſel.

Then ſet the Gauge point 18.95, to 36 the Tuns depth; then juſt againſt 65.6 is 432 Ale Gallons the Content.

But if you ſet the Gauge Point for an Ale Barrel at 107.19 to 36 the depth, then right againſt 65.6 the mean Diameter, is 13 Barrels and near a half or 15 Gallons the near Content required.

But if you ſet 113.69 the Gauge Point for a *Beer Barrel* to 36 the depth, then right againſt 65.6 is juſt 12 *Barrels of Beer*.

If you have a Decimal Fraction over, ſeek it in the Scale to 100, and juſt againſt it is the Firkins and Gallons over. *Example*, Suppoſe the Decimal Fraction over be 35, then juſt againſt 35 is 1 Firkin, 3 Gallons, and $\frac{1}{2}$, the proper Fraction of a *Barrel* required.

Sect. 4.

Sect. 4. *For great Square Veſſels.*

1. For Square Veſſels, the Gauge Point for a *Beer Barrel*, is at 100.76, for an *Ale Barrel* at 95. Then for right Square Veſſels, ſet the Gauge Point, to the depth on the double Line, then right againſt the ſide of the Square counted on the ſingle Line, is the Content in Barrels on the double Line. *Example*, At 118 Inches, 3 ſquare and 30 Inches deep ſet 100.76 to 30, then juſt againſt 118.3 the ſide of the ſquare, is 41 Beer Barrels and 25 parts (or 1 Firkin) the Content.

2. When the Veſſel is a long Square, as ſuppoſe 140 Inches long, and 100 Inches broad, find the Square equal thus, ſet 100 on the ſingle Numbers to 100 on the double Numbers, then juſt againſt 140 on the double Numbers, is 118.3 on the ſingle Numbers, the ſide of the Square equal: Then by the firſt you may have the Content.

3. Or by the 5th Rule of the 9th Section of the *Glaſiers Rule*; performed thus by the otherſide of the Rule, by two Workings.

Workings. *Example*, To find the Content of this Veſſel in *Ale Barrels* without the Square equal.

Set 95 the Gauge Point to 100 the breadth, then juſt againſt 140 the length is, 147.5 a fourth, then ſet the the Gauge Point 95 to this fourth, then juſt againſt 30 the depth, is 46 *Ale Barrels* and $\frac{1}{2}$ the ſolid Content.

4. Or having the ſide of the Square equal and the depth, work thus.

Set the Gauge Point 95, to 118.3 (the ſide of the Square equal) to 100 and 140, then juſt againſt 30 the depth is 37.30 a fourth: Then juſt againſt 37.30 found on the other ſide, is 46 *Barrels* and $\frac{1}{2}$.

Many other ways you may find in the *Practical Ganger*, but theſe may ſuffice in this place.

When the Square Tuns are Taper, find a Mean between the ſide of the Square found at the top and bottom, by *Rule* 2. of this *Section*.

F I N I S.

To find the Lengths of the Rafters and Hips, and the Angles at the foot, the top, and outside, in square, level, and taper Frames, at true pitch, or any greater or lower pitch, by the 30 Scales and Chords, and by Protraction with Scale and Compasses.

FOr the more easie understanding of the former and following Discourse about Roofs, consider, and draw if you please the four Figures following, *viz.* One for Square Frames, the second for bevelling Frames at one or both ends.

The third for taper Frames, broader at one end than at the other, and bevelling at each end also.

The fourth for Purloyns and Rafters in a bevel end Frame.

First, For Square Frames. Figure 1.

Let ABCD represent the raising Piece of a square House, AB and CD 16 Foot broad, AC and BD the length 30 foot long.

With a fit and convenient Scale, as the 30 or 40 Scales, draw the long Square ABCD, then draw the Line E E just in the middle between AB and CD, through the length.

Also lay AE from A to F, and from B to F, and from C to F, and from D to F, and draw the Lines F and F at each end cutting the Line E E in the Point G.

1. Then draw the four Diagonal Lines AG, BG, CG, and DG, produced at both ends, if you please.

Then Consider whether you intend to have the Roof true Pitch or more or less.

If true Pitch, then seek for 16 Foot the breadth of the House on the 40 Scales, and just against it on the 30 Scales is 12 foot the length of the Rafter: then seek 12 the length of the Rafter, on the 40 Scales, and just against it on the 30 Scales, is 9 Foot the perpendicular (being but 3 Quarters of 1 Inch too much.)

So

So that you may observe that the length of the Rafter is $\frac{1}{4}$ of the breadth of the Frame, and the perpendicular is $\frac{1}{4}$ of the length of the Rafter, in true Pitch or *London* Roofs.

In all other Roofs more or less than true Pitch, the breadth of the Frame given, and the perpendicular resolved on, then set the 30 Scales square, and count the half breadth of the Frame on one Leg, and the Perpendicular on the other, then the = distance between, is the length of the Rafter; and the half Diagonal Line, or the measure from the Corner to the King Post, counted on one 30 Scales, and the perpendicular on the other, the = distance between is the length of the Hip.

Or find them thus by Protraction.

2. Take $\frac{1}{2}$ of the breadth of the Frame, being 18, found in this *Example*, from your Scale, and set one Point in A, and cross the middle Line F in H, and then draw A H and B H for the Rafters at both ends, also lay the Extent A H from E to K at both ends, and draw A K and B K for the Hips.

Or rather take E H the perpendicular, and lay it from G to M, on the 4 Diagonal Lines extended; and draw A M, B M,

C M, and D M, for the 4 Hips (equal to the other.)

Then find the exact middle between A G, B G, C G, and D G, in the Points L, then find the Neareſt Diſtance from the Points L to A M, B M, C M, and D M, and lay it from L to N at each corner.

Then Laſtly, Lines drawn from N to E and E, make the Angles E N E the back of the Hip Rafter required 116 degrees,

The Angle M A G is the Hips Angle at foot, and the Angle *A M G* is the Hips Angle at K the Top or King Poſt.

The Angle A H E is the Angle at the top of the Rafter, and H A E the Foot of the Rafter, all which you may meaſure by the Chords.

Thus take the Extent from the the Angular Point H (as ſuppoſe A H E, the middle Letter being always the Angular Point) to the ſide H E, and mark the ſame Extent on the Line or ſide H A.

Then make the ſame Extent a = in 15 and 15, right againſt 60 of the Chords.

3. Then the meaſure from E to the mark made in the Line H A carried = ly till it ſtay in like parts, juſt againſt them in the Chords is the Angle required, as here 41 50 being read as Chords.

Or take the whole length of any one

Line

Line, and make it a = in 30,, ſetting the other 30 Scale to the Neareſt Diſtance. Then the Neareſt Diſtance from the firſt meaſured Line to the other in the Figure, being carried =ly till it ſtay at the Neareſt Diſtance on the 30 Scales, the fixed Point ſhall ſhew 41.50, being read as Sines, calling 60 but 30, and 180 but 90 in Sines.

To find theſe Angles by the Sines and Lines (or any other fit Scale) on the other ſide.

Firſt for the Rafters at foot and top.

Take — 12 Foot the Rafters length, from the 30 Scales, make it a = in the Sine of 90 the Angle A E H, laying the Thred to the Neareſt Diſtance, noting the place.

Then take out — 9 Foot H E the perpendicular from the ſame 30 Scale, and carry it = between the Sines and the Thred, till it cut the Thred at Neareſt Diſtance, and the Compaſs Point will ſtay at 48.10 the Angle at foot required.

So alſo — 8 foot A E the half breadth of the Frame, carried in like manner, will ſtay at 41.50 the Angle at top,

2. *For the Hip Angles.*

As — 14.4½ A M the Hips length, to the = Sine of A G M 90, so is — 9 foot the perpendicular E H to = Sine of M A G 38.22.

So also is — A G the half Diagonal 11.4 to the = Sine of A M H the Hips Angle at the top or King Post required, 51.38.

3. *For the Back of the Hip.*

As — 13.4 the Neareſt Diſtance from A to B K, to = Sine 90 B O A, ſo is — A G the half Diagonal, to = Sine of 58. 02, F N M half the Angle on the back, ſo is — 9 foot E H the perpendicular, to the = Sine of 42 24, the Pen-houſe Boards Angle at Foot.

Or find half the Angle of the Hips back as before in page 74 by Numbers and Artificial Tangents or Equal Parts and Natural Tangents.

2. To

2. *To find the Lengths and Angles of Rafters, and Hips, in parallel Frames bevelling at one or both ends, as here, 4 foot in 16 the breadth.*

Let A B C D in the second figure represent the Frame or raising Piece of a House of 16 foot broad at the Nearest Distance over, and A C 32 foot long.

Draw the figure by a fit Scale, as A B C D, also a Line along the whole length in the middle between A and B, as E and E, and in the middle between E and E draw another Line perpendicular to E E as 1, 1.

Then lay the half breadth A E from A B C D to F at each corner, and draw F F parallel to each bevel end, cutting E E in G.

Then draw the 4 Diagonal Lines A G, B G, C G, D G, produced at each end.

Then the middle Line right over 1, 1, being 16 foot, if you make the Roof true pitch, the Rafter will be 12 foot, 3 quarters of 16, and the perpendicular 9 foot, 3 quarters of 12 foot the Rafter.

If you alter the perpendicular, you vary all the rest.

1. Having the Neareſt Diſtance over, and the feet bevelling, to find the length of the bevel end, and the Angles at each corner. Open the 30 Scales ſquare, take the = Extent from the Neareſt Diſtance over (in this *Example* 16) to 4 the feet bevelling, and meaſure it — from the Center, and it gives 16.6 the bevel end.

Then as — 16.6 to = Sine of 90, ſo is — 4 foot to = Sine of 14 degrees, the Angle A B 2.

So is — 16 foot to = Sine of 76 the Angle A B F or B A 2, and 14 added to 90, makes 104 the Angle at A the blunt end: or 14 taken from 90, remains 76 the ſharp Angle at B.

(The ſame is at the other end, if the bevelling be equal, or elſe not.)

2. Or you may find theſe Angles by the 30 Scales, and the Line of Tangents over the Chords thus:

Make Lateral 16 foot a = in 15, and 15 right againſt the Tangent of 45, then — 4 foot the quantity of bevelling taken from the ſame Scale that 16 was, carried parallelly, ſhall ſtay at 3 foot 9 inches, in the 30 Scales right againſt the Tangent of 14 degrees, the Angle required, *viz.* A B 2.

3. Alſo

3. Alſo if you make — 16.6 a = in 30 and 30, right over the Chord of 180, which is the Sine of 90, then — 16 foot carried = ly, ſhall ſtay at 29 foot $1\frac{1}{2}$, right againſt 152, whoſe half is 76, alſo — 4 foot carried likewiſe, ſhall ſtay at 7 foot 3 inches, right againſt the Chord of 28, whoſe half is the Sine of 14 the Angle found as before.

4. If the ends are not equal, the perpendicular to the long middle Line, *viz.* 1, 1, in the middle, or the perpendicular reſolved on, with the half breadth in each place, and half Diagonals of the Frame, will give the length of every Rafter and Hip.

This digreſſion well conſidered, may be of more uſe than at preſent you may apprehend or conceive of; but to proceed.

5. The perpendicular in this *Example*, being 9 foot, ſet the 30 Scales Square, and and take the = Extent from 8.3 half the bevel end, to 9 the perpendicular, and meaſure it from the Center, and it gives 12 Foot 3 Inches the length of the Rafters at the bevel end, and remember a Rule laid to 8.3 and 9, and a bevel ſet as in *page* 67 and 69, gives the Angles at foot and top, or by Protraction $\frac{1}{4}$ of 1, 1, *viz.* 12 Foot laid from A and B, croſſing

one another, gives the Point I, A I and B I represent the pair of Rafters for the bevel end A B 12 foot 3 Inches long.

6. Then for the Hips length by protraction, take the Extent E I the perpendicular 9 foot, and lay it on the Diagonal Lines extended from G to L at each end, and draw the Lines A L, B L, C L, and D L, for the 4 Hip Rafters.

And lay them also inward or outward from A B C D to K, and draw those Lines for the 4 proper Hips.

Also you may find the Hips length by the 30 Scales, Set the 30 Scales Square, and count the perpendicular 9 on one Leg, and the Diagonal A G 10.2 on the other, and the = Extent between, measured from the Center, gives 13.7 for the shorter Hip A K.

Also take the = Extent from 9 Foot to 13 Foot the longer Diagonal, and measure it from the Center, and it gives 15 Foot 10 Inches the longer Hip B K.

7. The Diagonal Lines are found by the Rule thus:

Take 104 the Angle at A, from the Chords —ly, make it = in 15, and 15 the Chord of 60; then the = Extent from 8.3 the half bevel end, gives

13

13 the longeſt Diagonal Line B G.

Alſo take the —— Chord of 76, make it a = in 15 and 15, then take = 8.3, and it being meaſured from the Center, gives 10.2 the ſhorter Diagonal Line A G.

8. Then to find the mould or back of the Hip Rafters by Protraction.

Find the middle between A G, B G, C G, and D G on the 4 Diagonal Lines, as the 4 Points M in the ſecond Figure do ſhew.

Then from the 4 Points M take the Neareſt Diſtance to the Hips A L, B L, C L, D L, and lay it ſeverally from M to N on every Diagonal Line toward the corners A, B, C, D, then Lines drawn from N to F and E at every corner, gives the back or mould, or out ſide Angle, of every Hip required.

9. To do the like by the Rule or 30 Scales.

Firſt, you muſt find the Neareſt Diſtance from A to the Hip B K, and from B to the Hip A K thus.

Note, The longeſt Hip and bevel end taking leſs than ½ the feet and part bevelling, gives the leaſt Neareſt Diſtance.

Take

Take B K the longeſt Hip between your Compaſſes, *viz.* 15.10, ſet one Point in 16.6, the bevel end A B, and cloſe the other 30 Scale till the other Point falls on 15.10 in the other 30 Scale, then the Lines ſo ſet, the Neareſt Diſtance from 14.6 two foot leſs than 16.6 the bevel end, by half of A 2, 4 foot bevelling to the common or innermoſt Line on the other 30 Scales meaſured from the Center, gives 12.4 the Neareſt Diſtance from A to *B K*.

Alſo take A K the other Hip 13.7, make it a = in 16.6 and 13.7, then the neareſt Diſtance from 18.6, 2 Foot more than 16.6, gives 14.8 the Neareſt Diſtance from *B* to *A K*.

10. Laſtly, for the back of the Hip A K make the Diagonal 13 *B G* or *E F*. a = in 7.4 the half of 14.8 the Neareſt Diſtance from *B* to *A K*, and the 30 Scales are ſet to the Angle; then = 30 and 30 meaſured in the Chords, gives 125 deg.

Alſo, for the back of the Hip *B K* make the Diagonal 10.2 A G or E F 2 = in 6.2, the half of 12.4, the Neareſt Diſtance from A to *B K*, and the 30 Scales are ſet to the Angle E N *F* the back: then = 30 and 30 meaſured on the Chords gives 110.30 the meaſure in degrees.

11. Here

11. Here Note, you use the cross *Diagonal* under the Hip, and the ½ Neareſt Diſtance, from the oppoſite corner to the Hip ſet up, to ſet the 30 Scales to the Angle of the Mould, or back of the Hip.

Note, That all theſe Angles are repreſented in the Figure.

L *B* G and A L G the Hips Angle at the top or King Poſt, L *B* G and L A G the Hips Angle at foot or raiſing, *F* N G half the Angle of the Hips back or mould, *F* N E the whole Angle at each Hip differing.

And they may be found by Numbers and Sines artificial, or by the Lines and Sines natural, on the other ſide, as thus, *F N* or *E N* taken from any Scale to *F M N*, or *E M N*, made a = Sine of 90, ſo is — *F M* or *E N* taken from the ſame Scale, to the = Sine of *F N M* half the back of the Hip, the Angle required.

You may come by the Meaſures of *F N* and *N M* by the Scale and Compaſſes: to tell other ways is to be tedious in this place, and needleſs alſo.

3. *For*

3. *For to find the Length of the Rafters, and Hips, and Angles, in taper and bevelling Frames.*

Let *A B C D* in the third figure represent a taper *Frame*: *A B* 14.3, *C D* 18.8, *A C* 35.4, *B D* 27.5, *E E* the length in the middle between *A B* and *A C* 31.3, *M M* the breadth in the middle, and square to the middle Line 15 foot 11 inches.

1. Then first to find the quantity of bevelling, a perpendicular let fall from *E* and E at each end, to the middle Line E E, and drawn on through the Lines *A B* and *B D* the measure from *A*, *B*, *C*, *D*, to the intersection measured on the Scale, will be two foot at each end, being half the quantity of bevelling, because counted from the middle Line.

2. To

2. To find the Angle at each end.

Take *E A*, *E B*, *E C*, *E D*, the half breadth of each bevel end, and lay it from *A* and *B* to *F*, and from *C* and *D* to *G*, and draw the Lines *F F* and *G G*, interſecting *E E* in *H* and *I*; then draw the *Diagonals A I* and *B I*, *C H* and *D H*, and *E G* and *E F* the croſs *Diagonals* under each Hip, then take each croſs *Diagonal* one after another, and make it a = in the half bevel end at each corner, and it ſhall ſet the 30 Scales to the true Angle at each corner: thus the Angle G C E is 74 degrees, E D G 97.40, F B E 111 degrees, the Angle *F A E* 77.20.

3. *To find the length of the Rafters and Hips.*

Draw a Line in the middle of the length and Square to E E, as M M aboveſaid, 15 foot 11 inches; alſo lay half M M, both ways from M to N and N; then if you reſolve on true pitch, 9 foot will be a fit perpendicular; for if on the 40 Scales you ſeek 16, on the 30 Scales is 12¼ of it;

it; alſo againſt 12 on the 40 *Scales* is 9 on the 30 Scales, $\frac{3}{4}$ of it alſo. Then 12 foot laid from N interſecting at O, both ways, gives N O and N O a pair of middle Rafters, and M O the perpendicular 9 foot.

Then the 30 *Scales* ſet ſquare, count 9 foot on one *Leg*, and the meaſure from the middle *Line* to the place you intend to ſet your *Rafter foot*, at the other *Leg*: Then the = Extent between gives the true length of every *pair of Rafters*, and a Rule laid, and a bevel ſet, as before in *page 67 and 69*, gives the *Angles* at foot and top.

4. For the *Hips length* take every *Diagonal Line*, as *A I*, *C H*, *B I*, and *D H*, ſeverally between your *Compaſſes*, and make it = in it ſelf, and the common *perpendicular*, the 30 *Scales* being Square, and the = Extent between is the length of every Hip, and *a Rule* laid to the *Compaſs Points* ſo ſtanding in 9, and the *Diagonal*; *and a bevel* ſet to it, and the 30 *Scales*, gives the *Hips Angle* at the foot and the King Poſt, as in *page 69*.

5. To

5. *To find the Hips length and Angles by Protraction on the Scheame or Figure III.*

Lay the Perpendicular MO, 9 foot from I and H on every Diagonal Line to K and L, and draw AK, BK, GL, and DL, for the four Hips.

Then find the middle between AI, BI, CH, DH, as the four Points P, Q, R, S.

Then lay the Neareſt Diſtances from thoſe 4 Points to the 4 Hips laſt drawn from thoſe 4 Points toward the 4 Corners at T, V, W, X.

Then Laſtly, Lines drawn from T, V, W, X, to GE and EF, produceth the 4 Angles of every Hips back (or Mould required.

6. If you lay every Hip outward from every corner to 1, 2, 3, 4, 5, 6, having firſt raiſed 4 perpendiculars to AB and CD from the Points I and H, each Hip interſecting one another in the Points 1 and 2, and in the perpendiculars H 3, I 4, I 5, H 6, draw Lines from B to 1, from 1 to A, from A to 4, from 4 to 3, from 3 to D, from D to 2, from 2 to C, from C to 6, and from 6 to 5, and from 5 to B, where you began.

Then cut the Paper in the Lines last drawn, and bend the Paper on the Lines A B, B C, C D, and D A, and you shall see the true Figure of the Hip-Roof required, when the Points 1, 5, 4, and 3, 6 and 2, meet right over the middle Line and Points I H.

7. To find the Backs of the Hips by the 30 Scales.

First, You must find the Nearest Distances from every corner to the opposite Hip-Rib up; thus:

1. Take the Hips length A K 14,5 from the 30 Scales between your Compasses, and make it a = in 14,3 the bevel end, and it will fall short then the Nearest Distance from 12 foot 3 inches, 2 foot less than 14,3 the bevel end to the common Line on the other 30 Scales, gives 10.10 for the Nearest Distance from B to the Hip A I.

Then the Diagonal E F, 8 foot 8 inches taken between your Compasses, and made a = in 5,1 the half of 10.10 sets the 30 Scales on the Angle 106 degrees the back of the Hip F I E.

2. For E V E take B K 12,5, make it a Parallel in 14,3 and 12,5 in stretched the and T Nearest

Neareſt Diſtance from 16.3, 2 foot more than 14.3, to the common Line, gives 13.2 a Neareſt Diſtance from A to B 1.

Then the Diagonal EF 18.0 made a = in 6.7 the ½ of 13.2, ſets the 30 Scales to the back of the Hip EVF 129 degrees for = 30 meaſured ly on the Chords, give 129 degrees the Angle E V F.

3. For E W G take the Hip C B 14.9, make it a = in 18.8 the bevel end, and 14.9 it ſelf.

Then take out the Neareſt Diſtance from 20.8 two foot more than 18.8 the bevel end (by half the bevelling) to the common Line, and it gives 16 foot for the Neareſt Diſtance from D to G 2.

Then the Diagonal E G 14.0 made a = in 8.0, ½ 16 foot laſt found, ſets the 30 Scales to 123 the back of the Hip E W G.

4. For the Angle E X G take the Hip D L 17.1, make it a = in 18.8 the bevel end C D and it ſelf.

Then the Neareſt Diſtance from 16.8 a foot leſs than 18.8 to the common Line, gives 13.11 from G to D 2.

Then the Diagonal G E 11.3 taken between your Compaſſes and made a = in 6.11 ½ half of 13.11, ſets the 30 Scales to the Angle of 109 the back of the Hip G X E,

Note, That you may take the Nearest Distance from the opposite corner to the Hip set up from the Scheam or Figure drawn more easier than by the Operation last mentioned.

Note also, That in the last work you use the Diagonal Lines, being right cross under each Hip, and the Nearest Distance from the other corner to the Hip set up, which being observed, will a little methodize the work to remember it the more easily.

Also *Note*, That in finding the Nearest Distance for the blunt end of the Frame, you count more than the breadth of the bevel end by half the quantity of the bevelling, as here more by a foot the half of 4 foot the bevelling.

And at the sharp corner you take less than the bevel end by half the Feet and Parts bevelling.

4. To find the Length and Angles of Rafters and Purloyns in Bevil Frames.

Let A B in Figure 4. represent the bevel end of a Frame 5 foot out of square, as the Extent from C to B sheweth, A C the Square Line being 18 Foot, and A B the Bevel Line 18 5/8, and C B 5 Foot.

1. Then draw D E the middle Line, and F G and H I the two Lines at 1/4 of the breadth of the Frame. Also draw K L with two Lines to represent a pair of principal Rafters parallel to A C the Square Line, at any length you please from A to K, and from C to L, as here at 18 Foot.

2. Then to draw the Bevel Rafters, take F M, and lay it from F to N, and from I to O, and draw the double Lines A N and B O to represent a pair of bevel Rafters of 8 inches broad, whose length is from A to N, and from B to O, 1/10 the Width of the Frame, lying in legement to fit in the Purloins, to the Angles K A N and L B O. P Q the longest Purloin, R S the shortest Purloin, whose lengths you may measure by the Scale and Compasses, and Angles by the

the Line of Chords and a Bevel.

3. To find the length and Angles by the 30 Scales: Open the Rule square in the 30 Scales.

Then the Extent from 18 Foot the width over to 5 Foot the quantity of bevelling on the common Line, laid from the Center, gives 18 foot 8 inches the true length of the bevel end.

Also the Extent from 10.12 the perpendicular to 9.4 the half bevel end, gives 13.9 the true length of the bevel end Rafters.

4. For the Angle C A B, make A C 18 Foot a = in 15, then — B C taken from the same Scale, and carried = ly gives the degree in the Tangents just against it, as here 15 degrees 15 min. C A B.

Also for the Angle K A N make — A F 15 foot a = in 15, then half of C B, 27.6 inch, carried = ly, gives 9.30 for the Angle K A N, and so much more than 90, *viz.* 99.30 is the Angle O B I, and the Angle K L N is but 80.30, *viz.* 9.30 less than 90, for the Rafters to be laid in Legement, when scriped to the Purloin ends, and to the same Angles, *viz.* 99.30 is the upright of the gable end, and the back of the Raster that stands on the

blunt

blunt end B, and the other Rafter 80.30 being less than 90, for the sharp Angle A to be laid out of level Also the same quantity of 9.30, that it may be close when raised in its place.

5. To find the length of the Purloin, how much more or less than between the principal Rafters feet, one from another, into which it is framed. Set then 30 Scales to the Angle KAN 90.30, the count from the Center, the feet and inches that you intend the Mortice holes in the principal Rafters, for the tenons of the Purloins to go into, shall be above the Rafter feet, and take from thence the Neareſt Diſtance to the other common Line, and measure it from the Center — ly, and it gives the length, &c.

Example, The — Chord of 9.30 made a = in 15, the 30 Scales are set to 9.30, then the Mortice holes being 7 foot 3 inches above the Rafter feet, take from 7 foot 3 inches to the common Line at Neareſt Diſtance, and it gives — 1 foot 3 inches more than 13.8; *viz.* 15 foot near the length of the Purloin RS.

Also 1 foot 3 inch. taken from 18 foot 6, the diſtance between AK remains 17.3 the length of the *Purloin* between the Tenons at each end.

5. To

To find the length and Angles of Coller Beams in any Roof whatsoever.

Take the breadth of the Frame from the 30 Scales between your Compasses, make it a = in the Rafters length.

Then *Note*, The two Legs represent the two principal Rafters, and a Rule laid to the Compass Points, represent the raising Piece or Plate, and a bevel set to the Rule and Leg, gives the Angles at feet.

Then for the Coller Beam at any height between the raising and Center lay a Rule, and take the Extent between both on the upper and under side of the Coller Beam, and that shall be the exact length, adding Wood for Tennons, and a Rule laid and Bevel set, gives the Angle truly, where the Timbers are Square.

FINIS.